STATISTICAL EVALUATION

FISH AND SEDIMENT DIOXIN DATA

SPRING RIVER, MISSOURI

FIRST DRAFT

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TECHNICAL ASSISTANCE TEAM

Region - VII

ROY F. WESTON, INC.
Spill Prevention & Emergency Response Division
In Association with Jacobs Engineering Group Inc. Tetra Tech Inc.
and ICF Incorporated

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1.0 - EXECUTIVE SUMMARY

Between 1968 and 1969 the herbicide 2, 4, 5 the herbicide 2,4,5 - trichlorophenoxyacetic acid (2,4,5 - T) was manufactured for the military at a chemical company located adjacent to th Spring River area in Verona, Missouri. Between 1969 and 1972, the facility produced hexachlorophene, using 2,4,5 - Trichlorophenol as an intermediate. In both herbicide and hexachlorophenol production, 2,3,7,8 - tetrachlorodibenzo - p - dioxin was formed as a contaminant. The distillation residues (containing TCDD) from hexachlorophene production was disposed of at several locations in southwestern Missouri, resulting in several uncontrolled hazardous waste sites. Distillation residues were also used by some farmers along the Spring River because it was thought the residue would prevent hoof rot in cattle. The Spring River supports one of the major sport fisheries in southern Missouri. Because of the proximity of the chemical manufacturing company and hazardous waste disposal sites to the Spring River, the Environmental Protection Agency (EPA) developed a comprehensive dioxin monitoring program to detect the presence of dioxin in the Missouri Spring River Basin.

On November 16, 1981, the EPA Region VII collected fish and sediment samples from the Spring River for 2,3,7,8-TCDD analysis. The results of this effort confirmed the presence of 2,3,7,8-TCDD in fish tissues. Subsequent sampling has been conducted in December 1981, August 1982, December 1983 and August 1984.

On September 6, 1983, Syntex Agribusiness, Inc. entered into an Administrative Order with the EPA. Under this agreement, Syntex was to develop a fish and sediment monitoring plan for the Spring River in the vicinity of their Verona, Missouri facility. The "Verona Plant Fish and Sediment Plan" was accepted by the EPA on March 9, 1984. Under this order, the fish and sediment plan shall provide, initially, for sampling and analysis of Spring River fish for a five (5) year period extending up to twelve (12) miles downstream from the facility. Such period and/or distance may be extended or shortened by mutual agreement based on the results obtained. Therefore, the effort of this report is to analyze fish and sediment data from the Spring River for the period 1981 to late 1984 to determine if there is (1) no statistically significant decrease in the fish results at the 0.3 mile location downstream from the confluence of the Slough area and the Spring River (0.3 mile location) or (2) a statistically significant aggregated increase in the fish results at all other sampling points.

All of the fish and sediment data has been collected and selected from EPA files 107 and set up as a fish and sediment table (refer to table 1). The sediment statistical analysis was not analyzed due to the "flushing" situation of the Spring River, and also due to the lack of data. A one-half value of the detection limit was assigned to all fish samples which fall below the detection limit of 15 ppt. Pie charts were also set up for the convenience of comparing predators and/or bottom feeders within a year, or among years (refer to table 2A, 2B).

The fish statistical analysis was performed for fish data at location 1 (0.3 mile location) and at aggregated location 2,3,4,5 (3,6,9,12 mile location) (aggregated method). Linear least squared method and the Student's t distribution were applied for the analysis. The fish analysis was also performed by combining all the fish data at every location (combined method) for the Spring River fish study.

The fish statistical analysis for the Spring River fish study based upon the available data cannot be reliable since it has a very few sampling data, and also because of the discrepancy in data collections and the laboratory analytical methods. However, regardless of these factors in efforts of learning the extent of TCDD contamination on the Spring River, the results indicated that the whole fish data were more consistent and reliable than that of the fish fillets. Aggregated method showed no significant increase nor decrease of dioxin contamination levels with time at neither location 1 or aggregated location 2,3,4,5. Their results showed large values of significant figures (table 9 and table 10). The combined method showed a significant decrease of dioxin contamination levels with time as well as with distance on the Spring River. Their results showed small values of significant figures (5.1.B, 5.2.B, 5.3.B, 5.4.B)

Further fish sampling and analysis is needed for the Spring River fish study. Fish sampling and analytical efforts should be consistent; the bio-factors and effects of nature upon the Spring River should also be taken into consideration for the Spring River fish study.

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2.0 INTRODUCTION

2.1. Historical Background

2.1.1. As early as 1961, the chemical plant (*) at Verona, Missouri, located approximately 2 miles downstream from the Spring River headwaters, had been implicated as a source of water quality problems in the area. Initially, the problems consisted of black sludge, foul odors, and white, moss-like growth in the Spring River downstream from the plant. The Spring River supports one of the major sport fisheries in southern Missouri. Fishermen also take large numbers of non-sport fish by gigging during the off-season. Giggers generally harvest and consume a greater quantity of fish than other anglers. In 1981, tetrachlorodibenzo-p-dioxin (TCDD) was detected in gravel that had been removed from the Spring River approximately 2 miles downstream from the plant. This finding led to the decision by EPA personnel to collect and analyze fishes from the Spring River in the vicinity of Verona for TCDD.

2.1.2. The Spring River arises about three miles south of Verona, flows north past Verona, then turns west into Kansas and then south into Oklahoma. There it empties into the Lake of the Cherokees about 115 stream miles from Verona. In the upper reaches, the river is a typical Ozark stream with rocky gravel

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* The chemical plant is operated by Syntex Agribusiness, Inc., who manufactures animal feed supplements. The plant is owned by Syntex corpoation. The plant was purchased in 1969 from Hoffman-Taft Company who, in the late 1960's, made the herbicide 2,4,5-trichlorophenoxyacetic acid. Between 1970 and 1972, part of the plant was leased to North Eastern Pharmaceutical and Chemical Company (NEPACCO) who manufactured hexachlorphene, a germicide.

bottom and intermittent riffle areas separated by quiescent pools. There is little apparent sift deposition in the upper reaches and, in fact, the stream is a source of gravel for various construction activities. The upper reaches of the stream are subject to flooding on a fairly regular basis.

Species of fish in the river (Missouri portion) include red horse, suckers, sunfish, bass, carpsucker, bluegill, carp and catfish. The Missouri Department of Conservation has described the Spring River as being the most popular bass fishing stream in southwest Missouri and a 1977 survey estimated the economic value of the fishing recreation to be worth approximately 0.75 million dollars per year to the local economy. In addition to the fishing by rod and reel, gigging is also popular on the Spring River. This activity is of primary concern to state health officials because of the quantity of fish obtained and consumed in this manner.

2.1.3. In October 1981, the EPA Region VII determined that fish and sediment from the Spring River should be collected for 2,3,7,8-TCDD analysis. The first fish and sediment samples analysis were collected on November 16, 1981. The results of this effort confirmed the presence of 2,3,7,8-TCDD in fish tissues. Subsequent sampling has been conducted in December 1981, August 1982, December 1983 and August 1984.

2.1.4. On September 6, 1983, Syntex Agribusiness, Inc. entered into an Administrative Order with the EPA. Under this agreement, Syntex was to develop a fish and sediment monitoring plan for the Spring River in the vicinity of their Verona, Missouri facility. The "Verona Plant Fish and Sediment Plant" was submitted by Syntex to the EPA on October 12, 1983. After review, comments, and revisions, a revised plan dated March 9, 1984 was accepted by the EPA.

2.2. Objective

2.2.1. The Administrative Order stated that the Fish and Sediment Plan shall provide, initially, for sampling and analysis of Spring River fish for five (5) year period extending up to twelve (12) miles downstream from facility. Such period and/or distance may be extended or shortened by mutual agreement based on the result obtained. EPA may extend the initial five (5) year period at one year intervals and at twelve (12) mile increments for up to 5 years past this initial sampling period when (1) no statistically significant decrease in the fish results has been observed at the 0.3 mile location downstream from the confluence of the slough area and the Spring River or (2) a statistically significant aggregate increase in the fish results has been observed at all other sampling points.

2.2.2. Therefore, the specific objectives of this report were to:

(1). Obtain fish and sediment data from 1981 to late 1984.

(2). Summarize data and plot.

(3). Apply statistical methodology set forth in the approved "Verona Plant Fish and Sediment Plan" and prove if there is:

a. - No statistical decrease in the fish at the 0.3 mile location downstream from Syntex.

b. - A statistical significant aggregated increase in the fish results at all other sampling points.

3.0 BACKGROUND AND ANALYTICAL METHOD

In measuring the presence of dioxin in the environment surrounding the area of Verona, Missouri, many physical, chemical, and biological factors were considered. In the following subsections, the chemical structure, formation, and physical transport of tetrachlorodibenzo-p-dioxin (TCDD) through water and sediment is discussed. The ways in which TCDD is absorbed and the levels at which it is toxic in fish, and benthic macroinvertebrates are also addressed in detail.

3.1 Chemistry of Chlorinated dibenzo-p-dioxin

3.1.1. Chemistry Structure

A dioxin is any member compound of a family of compound known chemically as dibenzo-p-dioxins. Each member of this chemical family has as a nucleus a triple ring structure consisting of benzene rings interconnected through a pair of oxygen atoms. This general dioxin structure as well as the methods by which chlorinated phenols may react to become dioxins are illustrated in Figure A.

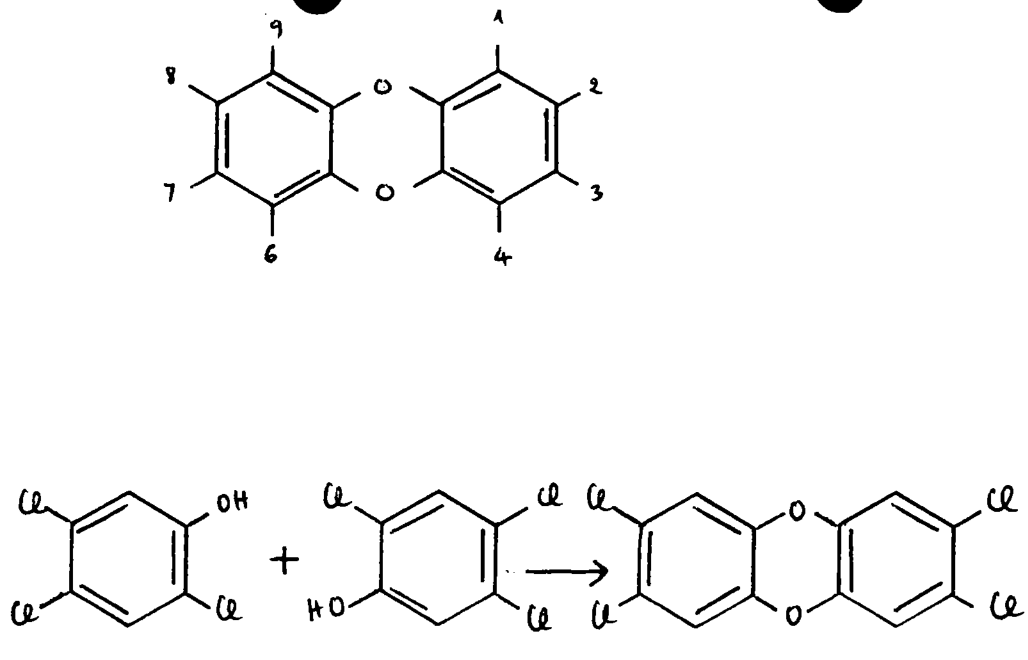


Figure A : Chemical Structure of tetrachlorodibenzo - p- dioxin (TCDD)

Theoretically, there are 75 different chlorinated dioxins, each with different physical and chemical properties, differing only in the number and relative position of the chlorine atoms on the dioxin nucleus. Because of the parallel or "mirror image" similarity of structure about many axes of the dioxin nucleus, the total number of different isomers for each group of chlorinated dioxins has been estimated. For example, of the 75 identifiably different dioxins there are 22 isomers of tetrachlorodibenzo-p-dioxin (TCDD).

3.1.2. Dioxin Formation

Dioxins are made by condensing catechols with polychlorinated benzenes. They are also easily generated by heating chlorinated phenols.

A dioxin can form any time the following two conditions exist in the precusor chemical:

(1) An ortho-substitued benzene ring in which one of substituents contains an oxygen atom attached directly to the ring.

(2) One of the substituents is capable of reacting with and being displaced by the oxygen atom.

These conditions can be met by many compounds, but probably the chlorinated phenols and their sodium or potassium salts are the largest class of potential precusors. Not all potential precusors, however, are reactive enough to produce a high dioxin yield.

The production of dioxins usually occurs with low yields and under specific or unusual conditions. Dioxin formation is generally determined by temperature. Temperature favorable for dioxin formation range from about 180 to 400°C. The presence of dioxins has been reported in the combustion of herbicides, chlorinated phenols, PCBs, fly ash, and cigarette smoke. Once formed, the dioxin nucleus is quite stable, and decomposition does not occur until temperatures of approximately 800°C or higher are reached.

3.2. Physical Transport.

3.2.1. Water

The water solubility of TCDD is 0.2 ppt (United State Environmental Protection Agency [EPA] 1980). Since TCDD binds rather tightly to soil particulates, and the water solubility of TCDD is so low, the amount washed out of soils is small compared to the amount present in soil. The equilibrium constant for partitioning between water and soil for TCDD is given by the formula:

$$Cs = Ksw . (Cw) \exp. 1/n$$

where:

Cs : concentration of TCDD in soil

Cw : concentration of TCDD in water

Ksw : partition coefficient for soil and water, and

1/n : empirical exponent.

Using data by Isensee and Jones (1975), JRB Associates (Veterans Administration 1981) calculated a Ksw by assuming n=1 in the above equation. From the six sets of data in the Isensee and Jones paper, JRB Associates estimated that the partition coefficient (Ksw) lies between 11,000 to 21,000. This would mean that less than 0.009% of the TCDD in soil would distribute into the water phase.

However, the Ksw values were apparently calculated for soil with moderately with low organic content. Thus, soils with a higher partition coefficients and less than 0.0005% of the TCDD would partition into the water phase. If similar calculations are made using findings from the Nash and Beall study (1978), the Ksw for their soil would be approximately 125,000; in other word, only about 0.0008% of TCDD would be removed by the water phase.

3.2.2. Sediment

The accumulation of TCDD and TCDD-related compounds in sediments has been reported by many investigators (Pierce et al.

1980; Stalling et al. 1981; Hites and Avilla (1980) reported that organic compounds with water solubilities of less than 5,000 ppb and with a n-octanol/water partition coefficient greater than 10 exp. 5 will accumulate in sediments. TCDD solubility is 0.2 ppb, and even though the n-octanol/water partition coefficient is not known, TCDD does tend to accumulate in sediments.

TCDD's affinity for accumulating in sediments has environmental significance, since organics having a low water solubility usually become associated with the sediments where they persist for a longer period of time and are released at very slow rates into the moving water. Thus, the sediment and not the water becomes the medium of sampling interest. Futhermore, low-level but chronic exposure to such a chemical increases the likelihood of accumulating harmful levels in target organism within the sediment and water.

Hites and Avilla (1980) evaluated sedimentary accumulation of industrial organic compounds discharged into a river system. They found TCDD in the effluent and reported that many organic compounds accumulated in the river sediments where they are stable and built up to high concentrations. In their study, the concentrations of organics decreased with the depth of sediment and with increasing distance from the source.

3.3 Biodynamics

3.3.1 Fish

Since different fish species bioconcentrate dioxin at different rates, the proper selection of fish species used for monitoring dioxin levels in the aquatic environment is essential when determining the degree and extent of TCDD contamination.

Some examples of various bioconcentration factor (BCI) are 24,000 for mosquito fish, 2,000 for catfish, and 6,660 for rainbow trout (Isensee and Jones 1975; Dow Chemical Company, 1978). The higher BCF values demonstrate the potential for TCDD to bioconcentrate in the aquatic environment. Furthermore, since these authors did not report that BCF values were measured at steady states, the potential for bioaccumulation may be even higher.

Factors affecting dioxin bioconcentration in fish are metabolism, fat content, age, and feeding habits. Generally, older fish and fish with higher fat content bioconcentrate TCDD to higher levels (Bache et al, 1972). Similarly higher tropic levels of fish accumulate higher concentrations of TCDD (biomagnification).

In additional considerations for developing a monitoring strategy are fish abundance, fish distribution, and migration patterns. It is also important to sample fish for environmental contaminants during the same time period each year because contaminant levels in fish fluctuate on a seasonal basis, particularly when fish are spawning (Wilfred 1982). When spawning, fish should contain the highest TCDD levels since TCDD lipophilic and fish build-up a large body of reproductive materials high in fats. Therefore, sampling fish during this time period will provide data on maximum TCDD levels in fish.

3.4 Analytical Method - General

The following methods will be applied in the fish statistical analysis of the Spring River, Missouri.

3.4.1 Linear Regression

In linear regression there are three important values, r, m, b. The correlation coefficient r shows the relationship between two variables for a particular sample. The value of r is between -1 and 1. If r equal -1 or 1, all points on the correlation diagram are on a line. The further the value of r is from -1 and 1, the less the points mass about the line and the less reliable is the correlation. If r is greater than 0, it shows a positive correlation (y is in proportion to x) and if r is less than 0, it is a negative correlation (y is inverse proportion to x).

The equation for the straight line is y = mx + b. The point at which the line crosses the y axis is b (intercept). The slope is m.

$$y = mx + b \quad (1)$$

$$r = \frac{S_{xy}}{\sqrt{S_{xx} . S_{yy}}} \quad (2)$$

$$m = \frac{S_{xy}}{S_{xx}} \quad (3)$$

$$b = \bar{y} - m\bar{x} \quad (4)$$

where:

r : correlation coefficient

m : the slope

b : the intercept

$\bar{x}$: average value of x(i) = $\frac{\Sigma x_i}{n}$

$\bar{y}$: average value of y(i) = $\frac{\Sigma y_i}{n}$

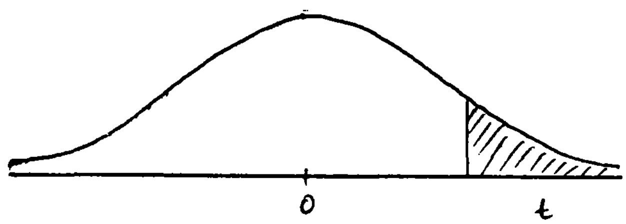
Sxx : $\Sigma x^2 - \frac{(\Sigma x)^2}{n}$ (5)

Syy : $\Sigma y^2 - \frac{(\Sigma y)^2}{n}$ (6)

Sxy : $\Sigma xy - \frac{\Sigma x . \Sigma y}{n}$ (7)

n : number of samples

3.4.2 Student's t distribution applied to confidence limits on slope and intercept values.



When using the linear least squares method to fit the straight line,

$$y = mx + b$$

to a set of n values of xi and yi, the Student's t distribution, with (N-2) degrees of freedom, should be used to estimate confidence limits. If μ is the statistically true value of the slope m, and β is the true value of the intercept b (i.e., m $\to \mu$ and b $\to \beta$ as N $\to \infty$) then

$$\mu = m \pm t . s \sqrt{\frac{N}{N \Sigma (x)^2 - (\Sigma x)^2}} \quad (8)$$

$$\beta = b \pm t . s \sqrt{\frac{\Sigma (x)^2}{N \Sigma (x)^2 - (\Sigma x)^2}} \quad (9)$$

where:

$$s^2 = \frac{1}{N-2} \sum (y - mx - b)^2 \quad (10)$$

The value of t is selected from tables of the Student's t distribution, using (N-2) degrees of freedom and the desired confidence limits (refer to table 4).

For example, if one wants to place 95% confidence limits ($p = 0.05$) on the slope and intercept derived from a set of 6 points, then using 4 degrees of freedom, the probability is 0.025 (The probabilities indicate the percent of the area in both tails of the curve (to the right and left of the mean) beyond the indicated value of t. Therefore, the probability $p = 0.05$ means that there will be 0.025 of the area in each tail beyond at t - value) that $t \geq 2.776$. Therefore the probability is 0.95 that $-2.776 \leq t \leq +2.776$. So far the 95% confidence limits, the value $t = 2.776$ would be used in the above formulas.

The Student's t distribution is applied to determine significant figures when using only a few points to estimate both the mean and the standard deviation.

3.4.3 General equation of TCDD concentration as a dependence of time and distance on the Spring river

$$\ln y(i) = \ln B0 + B1.T + B2.X + e(i) \quad (11)$$

where:

y(i) : TCDD concentration of i sample

T : Time (year)

X : Distance (mile)

B0,B1,B2 : constant

e(i) : random error of i sample.

In order to find the constant values of B1, and B2, the following steps are desired (refer to section 9.2)

3.4.3 (1) a. A graph of whole fish concentration (transformed data) versus time for each location on the Spring River will be plotted using linear least squares method. The graphs then give:

$$\ln y1(i) = \ln B0,1 + B1,1.T + e1(i) \quad @ \text{ location } 1 \quad (12)$$

$$\ln y2(i) = \ln B0,2 + B1,2.T + e2(i) \quad @ \text{ location } 2 \quad (13)$$

$$\ln y3(i) = \ln B0,3 + B1,3.T + e3(i) \quad @ \text{ location } 3 \quad (14)$$

$$\ln y4(i) = \ln B0,4 + B1,4.T + e4(i) \quad @ \text{ location } 4 \quad (15)$$

$$\ln y5(i) = \ln B0,5 + B1,5.T + e5(i) \quad @ \text{ location } 5 \quad (16)$$

b. Using all of the above equations, calculate the data points for each year.

c. Plot a graph of TCDD concentration (calculated data from part b above) versus time, which is independent of locations, using linear least squares method

$$\ln y(i) = \ln B0 + B1.T + e(i) \quad (17)$$

d. Student's t distribution is then applied to calculate the confidence interval for the slope and intercepts values of the above equation (equation 17), and that should give a value of constant B1

$$\ln y(i) = (\ln B0 \pm \beta_1) + (B1 \pm \mu_1).T \quad (18)$$

3.4.3 (2) a. A graph of whole fish TCDD concentration (transformed data) versus distance on the Spring River for each year will be plotted using linear least squares method. The graphs then yield

$$\ln y1(i) = \ln^*,1 + B2,1.X + e1(i) \quad @ \ 1981 \quad (19)$$

$$\ln y2(i) = \ln^*,2 + B2,2.X + e2(i) \quad @ \ 1982 \quad (20)$$

$$\ln y3(i) = \ln^*,3 + B2,3.X + e3(i) \quad @ \ 1983 \quad (21)$$

$$\ln y_4(i) = \ln^{*}, \quad B_{2,4}.X + e_4(i) \quad @ \quad 1984 \quad (22)$$

b. Using all of the above equations, calculate the data points for each location.

c. Plot a graph of TCDD concentration (calculated data from part b above) versus distance, which is independent of time, using linear least squares method.

$$\ln y(i) = \ln B^{*} + B_2.X + e(i) \quad (23)$$

d. Student's t distribution is then applied to calculate the confidence interval for the slope and intercept values of the above equation (equation 23)

$$\ln y(i) = (\ln B^{*} + \quad) + (B_2 + \quad).X \quad (24)$$

3.4.3 (3) Similar method (refer to 3.4.3.1) will be used to analyze fish data for location 1 and for the combined location 2,3,4,5 in each year.

4.0 PROCEDURE FOR STATISTICAL ANALYSIS

4.1 The following steps which are suitable for data interpretation and also satisfied the statistical methodology set forth in the approved "Verona Plant Fish and Sediment Plan" are desired for the fish and sediment statistical analysis of the Spring River:

4.1.1 Collect all fish and sediment data

4.1.2 Set up a table of fish and sediment data in order of sample number, date of collection, result(s) and location. (Refer to table 1). The following steps are applied:

(1) Match up location and result of a particular sample to get its sample number.

(2) Match up sample number and result of a particular sample to get its location.

(3) Match up all resultant sources of a particular sample to get its up-date data.

(4) Gather all information of a particular sample to get a best description of its location.

4.1.3 Distinguish and verify bottom feeder and predator species for each year of collection. (refer to Table 1).

4.1.4 Verify five (5) locations on the Spring River for the statistical analysis. (refer to 9.1).

4.2.1 (a) Plot a graph of whole fish (bottom feeders) TCDD concentration versus time for each location on the Spring River (Figure 1A) using linear least squares method.

(b) Plot a graph of whole fish (bottom feeders) TCDD concentration versus time, which is independent of locations (Figure 1B) using linear least squares method.

4.2.2 (a) Plot a graph of fish fillet (bottom feeders) TCDD concentration versus time, at each location on the Spring River (Figure 2A) using linear least squares method.

(b) Plot a graph of fish fillet (bottom feeders) TCDD concentration versus time, which is independent of locations (Figure 2B) using linear least squares method.

4.2.3 (a) Plot a graph of whole fish (bottom feeders) TCDD concentration versus distance (location) for each year of sample collection on the Spring River (Figure 3A) using linear least squares method.

(b) Plot a graph of whole fish (bottom feeders) TCDD concentration versus distance (location), which is independent of time (Figure 3B) using linear least squares method.

4.2.4 (a) Plot a graph of fish fillet (bottom feeders) TCDD concentration versus distance (location for each year of sample collection on the Spring River (Figure 4A) using linear least squares method.

(b) Plot a graph of fish fillet (bottom feeders) TCDD concentration versus distance (location), which is independent of time (Figure 4B) using linear least squares method.

4.2.5 (a) Plot a graph of whole fish (bottom feeders) TCDD concentration versus time at location 1 and of the combined location 2,3,4,5 (Figure 5A) using linear least squares method.

(b) Plot a graph of whole fish (bottom feeders) TCDD concentration versus time, which is independent of locations (Figure 5B) using linear least squares method.

4.2.6 (a) Plot a graph of fish fillet (bottom feeders) TCDD concentration versus time, at location 1 and of the combined location 2,3,4,5 (Figure 6A) using linear least squares method.

(b) Plot a graph of fish fillet (bottom feeders) TCDD concentration versus time, which is independent of locations (Figure 6B) using linear least squares method.

5.0 RESULTS FOR THE SPRING RIVER STUDY

5.1.A. Whole fish (bottom feeders) TCDD concentration versus time at each location on the Spring River (figure 1A).

Location	TCDD conncentration vs. T	Correlation r
Location 1 - 0.3 miles downstream fr. Syntex	ln y(a) = -0.24T + 4.61 (b)	-0.3767
Location 2 - 3.0 miles downstream fr. Syntex	ln y = 0.02T + 3.60	1.000
Location 3 - 6.0 miles downstream fr. Syntex	ln y = -0.22T + 3.44	-1.000
Location 4 - 9.0 miles downstream fr. Syntex	———	——
Location 5 - 12 miles downstream fr. Syntex	ln y = -0.61T + 4.43	-1.000

TABLE 5: Whole fish (bottom feeders) TCDD concentration versus time at each location on the Spring River.

a - TCDD Concentration of i sample in ppt.

b - T time in year.

5.1.B - whole fish (bottom feeders) TCDD concentration versus time, which is independent of locations (Figure 1B)

$$\ln y = (-0.26 \pm 0.27) \cdot T + (4.02 \pm 0.37)$$

5.2.A. Fish fillet (bottom feeders) TCDD concentration versus time at each location on The Spring River (figure 2A)

Location	TCDD concentration vs. T	Correlation r
Location 1 - 0.3 miles downstream fr. Syntex	ln y(a) = -1.15T + 6.14 (b)	-0.9744
Location 2 - 3 miles downstream fr. Syntex	ln y = -0.59T + 3.42	-1.000
Location 3 - 6 miles downstream fr. Syntex	ln y = -0.81T + 4.32	-1.000
Location 4 - 9 miles downstream fr. Syntex	ln y = -0.34T + 2.04	-1.000
Location 5 - 12 miles downstream fr. Syntex	ln y = 0.09T + 0.90	0.3032

TABLE 6: Fish fillet (bottom feeders) TCDD concentration versus time for each location on the Spring River

a - TCDD concentration of i sample in ppt

b - Time in year

5.2.B - Fish fillet (bottom feeders) TCDD concentration versus time, which is independent of locations (Figure 2B)

$$\ln y = (-0.56 \pm 0.36)T + (3.36 \pm 0.43)$$

5.3.A - Whole fish (bottom feeders) TCDD concentration versus distance for each year of sample collection (Figure 3A)

Year	TCDD concentration vs. X	Correlation r
1981	$\ln y(a) = -0.09X + 3.89$	-1.000
1982	$\ln y = -0.17X + 4.82$	-0.8082
1983	-	-
1984	$\ln y = -0.16X + 3.83$	-0.9486

TABLE 7: Whole fish (bottom feeders) TCDD concentration versus distance for each year of sample collection

a - TCDD concentration in ppt

b - X distance in mile

5.3.B - Whole fish (bottom feeders) TCDD concentration versus distance, which is independent of time (Figure 3B)

$$\ln y = (-0.14 \pm 0.10).X + (4.18 \pm 0.43)$$

5.4.A Fish fillet (bottom feeders) TCDD concentration versus distance for year of sample collection.

Year	TCDD concentration vs. X	Correlation r
1981	ln y(a) = -0.19X + 3.41	-1.000
1982	ln y = -0.24X + 3.89	-0.9884
1983	ln y = -0.13X + 3.04	-1.000
1984	ln y = -0.04X + 1.28	-0.6194

TABLE 8: Fish fillet (bottom feeders) TCDD concentration versus distance for each year of sample collection.

a - TCDD concentration in ppt

b - X distance in mile

5.4.B Fish fillet (bottom feeders) TCDD concentration versus distance, which is independent of time (Figure 4B)

$$\ln y = (-0.11 \pm 0.26)X + (2.55 \pm 0.96)$$

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BY ______ DATE ______ DIV ______ SHEET ______ OF ______
CHKD BY ______ DATE ______ DEPT ______ W.O. NO. ______
PROJECT ______
SUBJECT ______

5.5. A. whole fish (bottom feeders) TCDD concentration versus time for location 1 and combined location 2,3,4,5.

Location	TCDD concentration vs. T	Correlation r
location 1 (0.3 mile location)	$\ln y(a) = (-0.24 \pm 1.77)T_{(b)} + (4.61 \pm 4.86)$	-0.3767
location *	$\ln y = (-0.22 \pm 1.27)T + (3.72 \pm 3.37)$	-0.9105

TABLE 9 : whole fish (bottom feeders) TCDD concentration versus time for location 1 and combined location 2, 3, 4, 5.

a - TCDD concentration in ppt

b - T time in year

* - Combined location 2, 3, 4, 5

5.5. B whole fish (bottom feeders) TCDD concentration versus time, which is independent of locations (result of table 9)

$$\ln y = (-0.21 \pm 0.28)T + (4.13 \pm 0.54)$$

5.6.A. Fish fillet (bottom feeders) TCDD concentration versus time for location 1 and combined location 2, 3, 4, 5

location	TCDD concentration vs. T	Correlation r
location 1 (0.3 mile location)	$\ln y = (-1.15 \pm 3.37)T + (6.14 \pm 10.49)$ (a) (b)	-0.9744
location (*)	$\ln y = (-0.44 \pm 0.37)T + (2.82 \pm 1.02)$	-0.9630

TABLE 10: Fish fillet (bottom feeders) TCDD concentration versus time for location 1 and combined location 2, 3, 4, 5.

a – TCDD concentration in ppt

b – T time in year.

* – Combined location 2, 3, 4, 5

5.6.B. Fish fillet (bottom feeders) TCDD concentration versus time, which is independent of locations (results of table 10)

$$\ln y = (-0.79 \pm 0.58)\,T + (4.47 \pm 1.13)$$

-

TABLE 1: SPRING RIVER FISH AND SEDIMENT DATA

LOCATION	LAB NUMBER FISH SPECIES (COMPOSITE)	DATE OF COLLECTION	FISH AGE YEARS	LABORATORY AND DATA (TCDD in ppt) NCTR W#	CNFRL W#	UNL W#	UNL F#	EPA VII W#
Spring River @ R.M. 0.7 S. of Verona - 117.2 miles upstream from Lake of Cherokees - 2.1 miles upstream from Syntex	AA2401-1 white sucker-B(a) -2 " " -3 " " -4 " " -5 " "	Nov. 16, 1981	4 3 5 5 4	NA	19	15 (15)	NA	25
	-6 Hog Sucker -7 " "		NA	NA	NA	NA	<16 (<16)	NA
Spring River @ R.M. 5.6 downstream Douger Ck. Confl - 112.3 miles upstream from Lake of Cherokees - 2.8 miles downstream from Syntex	AA2402-1 White Sucker-B(a) -2 " " -3 " " -4 " " -5 " "	Nov. 16, 1981	4 3 3 4 3	NA	36	39 (60)	NA	NA
	AA2402-6 White Sucker-B(a) -7 " " -8 " -9 " " -10 " "	Nov. 16, 1981	5 5 4 4 2	NA	NA	NA	17 (20)	NA
Spring River @ R.M. 4.3 downstream Douger Ck. Confl - 113.7 miles upstream from Lake of Cherokees - 1.4 miles downstream from Syntex - Station # 2	AA2403-1 White Sucker-B(a) -2 " " -4 " "	Nov. 16, 1981	3 2 NA	NA	NA	NA	15 (15)	NA
Spring River @ R.M. 11 - 107 miles upstream from Lake Cherokees - 8.1 miles downstream from Syntex	AA2404-1 White Sucker-B(a) -2 " " -3 " " -4 " " -5 " "	Nov. 16, 1981	4 4 4 3 2	NA	NA	NA	6 (6)	NA
	-6 Hog Sucker-B(a) -7 " "	Nov. 16, 1981	NA	NA	NA	NA	5 (5)	NA
	-8 Creek Chub-P(a) -9 " " -10 " "	Nov. 16, 1981	NA	NA	NA	<1	<8 (<8)	

TABLE 1 SPRING RIVER FISH AND SEDIMENT DATA (cont.)

LOCATION	LAB NUMBER FISH SPECIES (COMPOSITE)	DATE OF COLLECTION	FISH AGE YEARS	LABORATORY AND DATA (TCDD in ppt) NCTR W*	CNFRL W*	UNL W*	UNL F*	EPA VII W*
Spring River @ R.M. 3.2 N. of Verona - 114.8 miles upstream from lake of Cherokees - 0.3 miles downsteam from Syntex.	AA2405-1 White Sucker-B(a)		4					
	-2 " "		4					
	-3 Hog Sucker-B(a)		NA					
	-4 " "	Nov. 16, 1981	NA	55	37	52	NA	45
	-5 " "		NA			(120)		
	-6 " "		NA					
	-7 Creek Chub-P(a)		NA					
	-8 " "	Nov. 16, 1981	NA	NA	NA	NA	18	NA
	-9 " "		NA				(30)	
	-10 " "							
Celia's Spring River Trout Farm @ R.M. 0 - 118 miles upstream from Lake of Cherokees - 2.9 miles upstream from Syntex - Site 2	AA2406-1 Rainbow Trout-P(a)							
	-2 " "							
	-3 " "	Nov. 16, 1981	NA	<25	<1	<9 (<9)	NA	NA
	-4 " "							
	-5 " "							
Spring River @ R.M. 96 at Baxter Springs - 22 miles upstream from Lake of Cherokees - 93 miles downstream from Syntex - Site 14	SD5002-1 Carp-B(a)							
	-2 "							
	-3 "	Dec. 28, 1981	NA	NA	NA	(<3.0)	NA	NA
	-4 "							
Celia's Spring River Trout Farm @ 5.3 - 118 miles upstream from Syntex - Site 2	SD5003-1 Rainbow Trout-P(a)							
	-2 " "							
	-3 " "	Dec. 28, 1981	NA	NA	NA	(<0.81)	NA	NA
	-4 " "							
	-5 " "							
Spring River @ R.M. 36 - immediately N. of La Russell - 82.1 miles upstream from Lake of Cherokees - 33 miles downstream from Syntex - Site 11	SD5004-18 White Sucker-B(a)							
	-20 " "	Dec. 28, 1981	NA	NA	NA	(<1.2)	NA	NA
	-22 " "							
	-24 " "							
	-19 White Sucker-B(a)							
	-21 " "	Dec. 28, 1981	NA	NA	NA	NA	(<0.92)	NA
	-23 " "							
	-25 " "							

TABLE 1. SPRING RIVER FISH AND SEDIMENT DATA (cont.)

LOCATION	LAB NUMBER FISH SPECIES (COMPOSITE)	DATE OF COLLECTION	FISH AGE YEARS	NCTR W*	CNFRL W*	UNL W*	UNL F*	EPA VII W*
	SD5004-5 Small Mouth Bass-P(a) -6 " " -7 " " -8 " " -9 " " -10 " " -7 " "	Dec. 28, 1981	NA	NA	6.2	NA	NA	NA
Spring River @ R.M. 46, approximately 1.7 miles E - N.E. of Carthage, MO, 72.1 miles upstream from Lake of Cherokees - 43 miles downstream from Syntex - Site 12	SD5008-24 Spotted Suckers-B(a) -25 " " -26 " " -27 " " -28 " " -30 " "	Dec. 28, 1981	NA	NA	NA	<1	NA	NA
	SD5008-1 Largemouth Bass-P(a) -2 " " -3 " " -4 " " -5 " " -6 " " -7 " " -8 " " -9 " "	Dec. 28, 1981	NA	NA	2.54	NA	1	NA
	SD5008-33 Shorthead Redhorse-B(a) -34 " " -35 " " -36 " "	Dec. 28, 1981	NA	NA	1.1	NA	NA	NA
Spring River @ R.M. 69 N. of Gaylesburg, MO - 49 miles upstream from Lake of Cherokees - 66 miles downstream from Syntex - Site 13	SD5010-16 River Redhorse-B(a) -17 Shorthead Redhorse -18 " "	Dec. 28, 1981	NA	NA	0.8	NA	NA	NA

LOCATION	LAB NUMBER FISH SPECIES (COMPOSITE)	DATE OF COLLECTION	FISH AGE YEARS	NCTR W*	LABORATORY AND DATA (TCDD in ppt) CNFRL W*	UNL W*	UNL F*	EPA VII W*
Spring River @ R.M. 0.7 - 2.0 miles upstream from Syntex - Station # 1 - Site 5	OCL21001-[I] White Suckers-B(a) [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " "	Aug. 1, 1982	NA	NA	NA	ND	<5	NA
Spring River @ R.M. 0.7 - 2.0 miles	OCL21002-[I] Green Sunfish-P(a) [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " "	Aug. 1, 1982	NA	NA	NA	(40)	14	NA
N. of Verona @ R.M. - 0.27 miles downstream from Syntex - Station # 2 Site 2	OCL21003-[I] White Sucker-B(a) [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " "	Aug. 1, 1982	NA	NA	NA	(180)	40	NA
N. of Verona @ R.M. 3.2 - 0.27 miles downstream from Syntex - Station 2 Site 2	OCL21004-[I] Green Sunfish-P(a) [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] Smallmouth Bass [I] " " [I] " "	Aug. 1, 1982	NA	NA	NA	(200)	3	NA

TABLE 1. SPRING RIVER FISH AND SEDIMENT DATA (cont.)

LOCATION	LAB NUMBER FISH SPECIES (COMPOSITE)	DATE OF COLLECTION	FISH AGE YEARS	LABORATORY AND DATA (TCDD in ppt) NCTR W#	CNFRL W#	UNL W#	UNL F#	EPA VII W#
Spring River @ R.M. 7.9 - 5 miles downstream from Syntex - Station # 3 Site 6	OCL21007-[I] White Suckers-B(a) [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " "	Aug. 1, 1982	NA	NA	NA	(20)	15	NA
Spring River @ R.M. 7.9 - 5 miles downstream from Syntex - Station # 3 - Site 6	OCL21008-[I] Creek Chub-P(a) [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " "	Aug. 1, 1982	NA	NA	NA	35 45	15	NA
Spring River @ R.M. 14 - 11 miles downstream from Syntex - Station # 4 - Site 4	OCL21010-[I] Golden Redhorse-B(a) [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] " "	Aug. 1, 1982	NA	NA	NA	(25)	(2.5)	NA
Spring River @ R.M. 14 - 11 miles downstream from Syntex - Station # 4 - Site 4	OCL21011-[I] Smallmouth Bass(a)P [I] " " [I] " " [I] " " [I] " " [I] " " [I] " " [I] Green Sunfish [I] " " [I] " "	Aug. 1, 1982	NA	NA	NA	(40)	2	NA

LOCATION	LAB NUMBER FISH SPECIES (COMPOSITE)	DATE OF COLLECTION	FISH AGE YEARS	LABORATORY AND DATA (TCDD in ppt) NCTR W#	CNFRL W#	UNL W#	UNL F#	EPA VII W#
Spring River @ R.M. 15 - 12 miles downstream from Syntex Location 5	AAC401-[I](c)(b)	Dec. 15, 1983	NA	NA	NA	(d)(f)	<9	(d)(f)
Spring River @ R.M. 3.3 - 0.3 miles downstream from Syntex - Location 1	AAC403-[I](c)(b)	Dec. 15, 1983	NA	NA	NA	28	(d)(f)	(d)(f)
	AAC403-[I] White Sucker-B(a)							
	[I] " "							
	[I] " "							
	[I] " "							
	[I] " "	Dec. 15, 1983	NA	NA	NA	(d)(f)	20	(d)(f)
	[I] " "							
	[I] " "							
	[I] " "							
	[I] " "							
	[I] " "							
Spring River @ R.M. 3.2 - 0.3 miles downstream from Syntex - Location 1	BAC402-[I](c)(b)-B(a)	Aug. 1, 1984	NA	NA	NA	NA	4	NA
	BAC402-[I](c)(b)-B(a)	Aug. 1, 1984	NA	NA	NA	40	NA	NA
Spring River @ R.M. 5.8 - 3 miles downstream from Syntex - Location 2	BAC403-[I](c)(b)-B(a)	Aug. 1, 1984	NA	NA	NA	NA	3	NA
	BAC403-[I](c)(b)-B(a)	Aug. 1, 1984	NA	NA	NA	40	NA	NA
Spring River @ R.M. 8.9 - 6 miles downstream from Syntex - Location 3	BAC405-[I](c)(b)-B(a)	Aug. 1, 1984	NA	NA	NA	NA	3	NA
	BAC405-[I](c)(b)-B(a)	Aug. 1, 1984	NA	NA	NA	13	NA	NA
Spring River @ R.M. 11.9 - 9 miles downstream from Syntex - Location 4	BAC406-[I](c)(b)-B(a)	Aug. 1, 1984	NA	NA	NA	NA	2	NA
Spring River @ R.M. 15 - 12 miles downstream from Syntex Location 5	BAC408-[I](c)(b)-B(a)	Aug. 1, 1984	NA	NA	NA	NA	<2 <15	NA

TABLE 1: SPRING RIVER FISH AND SEDIMENT DATA (cont.)

LOCATION	LAB NUMBER FISH SPECIES (COMPOSITE)	DATE OF COLLECTION	FISH AGE YEARS	LABORATORY AND DATA (TCDD in ppt) NCTR W*	CNFRL W*	UNL W*	UNL F*	EPA VII W*
Spring River @ R.M. 3.2 - 0.3 miles downstream from Syntex - Location 1	BAC409-[I](c)(b)-B(a)	Aug. 1, 1984	NA	NA	NA	NA	4	NA
Unknown	BAC410-[I](c)(b)	Aug. 1, 1984	NA	NA	NA	(d)	(d)	NA
Unknown	BAC415-[I](c)(b)	Aug. 1, 1984	NA	NA	NA	(d)	(d)	NA
Unknown	BAC416-[I](c)(b)	Aug. 1, 1984	NA	NA	NA	(d)	(d)	NA
Spring River @ R.M. 11.9 - 9 miles downstream from Syntex - Location 4	BAC417-[I](c)(b)-B(a)	Aug. 1, 1984	NA	NA	NA	12	NA	NA
Spring River @ R.M. 15 - 12 miles downstream from Syntex	BAC418-[I](c)(b)	Aug. 1, 1984	NA	NA	NA	3	NA	NA
Unknown	BAC419-[I](c)(b)	Aug. 1, 1984	NA	NA	NA	(d)	(d)	NA

TABLE 1[illegible] SPRING RIVER FISH AND SEDIMENT DATA (cont.)

LOCATION	LAB NUMBER FISH SPECIES (COMPOSITE)	DATE OF COLLECTION	LABORATORY AND DATA (TCDD in ppt)
Unknown	AS2501-Mussel	Unknown (j)	ND
Unknown	AS2502-Mussel	Unknown (j)	ND
Unknown	AS2503-Mussel	Unknown (j)	ND
Unknown	AS2504-Mussel	Unknown (j)	ND
Unknown	AS2505-Mussel	Unknown (j)	ND
Unknown	AS2506-Mussel	Unknown (j)	ND
Unknown	AS2507-Mussel	Unknown (j)	ND
Spring River @ R.M. 3.2 - North of Verona - 0.3 miles downstream from Syntex	OCL21005-[I] Crayfish(g)(20) [I] " " [I] " " [I] " " [I] " " [I] " "	Jan. 1, 1983	9(f)
Spring River @ R.M. 3.2 - North of Verona - 0.3 miles downstream from Syntex	OCL21006-[I] Invertabrates	Jan. 1, 1983	12(f)
Spring River @ R.M. 11 - 8 miles downstream from Syntex	OCL21009-[I] Mussels (g)(18) [I] " " [I] " " [I] " " [I] " " [I] " "	Jan. 1, 1983	3(f)

TABLE [illegible] SPRING RIVER FISH AND SEDIMENT DATA (cont.)

LOCATION	LAB NUMBER FISH SPECIES (COMPOSITE)	DATE OF COLLECTION	LABORATORY AND DATA (TCDD in ppt) UNL	EPA VII
Unknown	AN0390- Sediment	1981	13,000(h) 570(i)	
Unknown	AN0391- Sediment	1981	NA(h) 49(i)	
Unknown	AN0392- Sediment	1981	100(h) 25(i)	
Unknown	AN0393- Sediment	1981	36(h) 6(i)	
Unknown	AN0394- Sediment	1981	6(h) 2(i)	
Unknown	AN0107-113- Sediment	1981	660(h) 130(i)	
US 69 BRDG, area @ r.m. 0.7 - South of Verona - 2.1 miles upstream from Syntex	SD0501- Sediment	Nov. 16, 1981		<10
Spring River @ R.M. 5.6 - 2.8 miles downstream from Syntex	SD0502- Sediment	Nov. 16, 1981		<20
Spring River @ R.M. 11, North of Verona, 8.1 miles downstream from Syntex	SD0504- Sediment	Nov. 16, 1981		<10
Spring River @ R.M. 3.2, North of Verona, 0.3 miles downstream from Syntex	SD0505- Sediment	Nov. 16, 1981		12
Celia's Spring River Trout Farm @ R.M. 0.2 - 9 miles upstream from Syntex	SD0512- Sediment	Nov. 16, 1981		<5

LOCATION	LAB NUMBER FISH SPECIES (COMPOSITE)	DATE OF COLLECTION	LABORATORY AND DATA (TCDD in ppt)
Unknown - Spring River at Hwy 60 bridge upstream from Verona	AC4301- Sediment	Sept. 14, 1982	<120 (f)
Unknown - Spring River before Verona	AC4302- Sediment	Sept. 14, 1982	<110 (f)
Unknown - Spring River near Hoberg	AC4303- Sediment	Sept. 14, 1982	<120 (f)
Unknown - Harvey Creek near Hoberg	AC4304- Sediment	Sept. 14, 1982	<160 (f)
Unknown - Spring River downstream from Mt. Vernon	AC4305- Sediment	Sept. 14, 1982	<120 (f)
Unknown - Spring River at LaRussel	AC4306- Sediment	Sept. 14, 1982	<100 (f)
Spring River, 12 miles downstream from Syntex - Location 5	AAC400- Sediment	Dec. 15, 1983	<9 (f)
Spring River, 0.3 miles downstream from Syntex - Location 1	AAC402- Sediment	Dec. 15, 1983	<27 (f)

W - whole fish
[I] - Lab sub. number is unknown
a - B - Bottom feeder / P - Predators
b - Fish species is unkown
c - Number of fish is unknown
d - Result is unknown
f - Laboratory analysis is unknown
g - Total species collected
h - Analysis of 2,3,7,8-TCDD and Coeluting Isomers in Sediment by GLC/HRMS
i - Analysis of 2,3,7,8-TCDD and pre-electing Isomers in Sediment by GLC/HRMS
j - These samples were analyzed by Brehm Laboratory, Wright State University, Dayton, Ohio 45435 (file # 107-25) The results sent to Robert L. Morby (chief, WMBR/ARWM) on Dec. 10, 1982. Therefore, these samples were definietly collected in 1982.
ND - Not Detected
CNFRL - Columbia National Fisheries Research Lab.
NCTR - National Center for Toxicological Research
UNL - University of Nebraska at Lincoln
EPA VII - Region VII Environmental Protection Agency Lab

F - Fish fillet
() - Total TCDD concentration

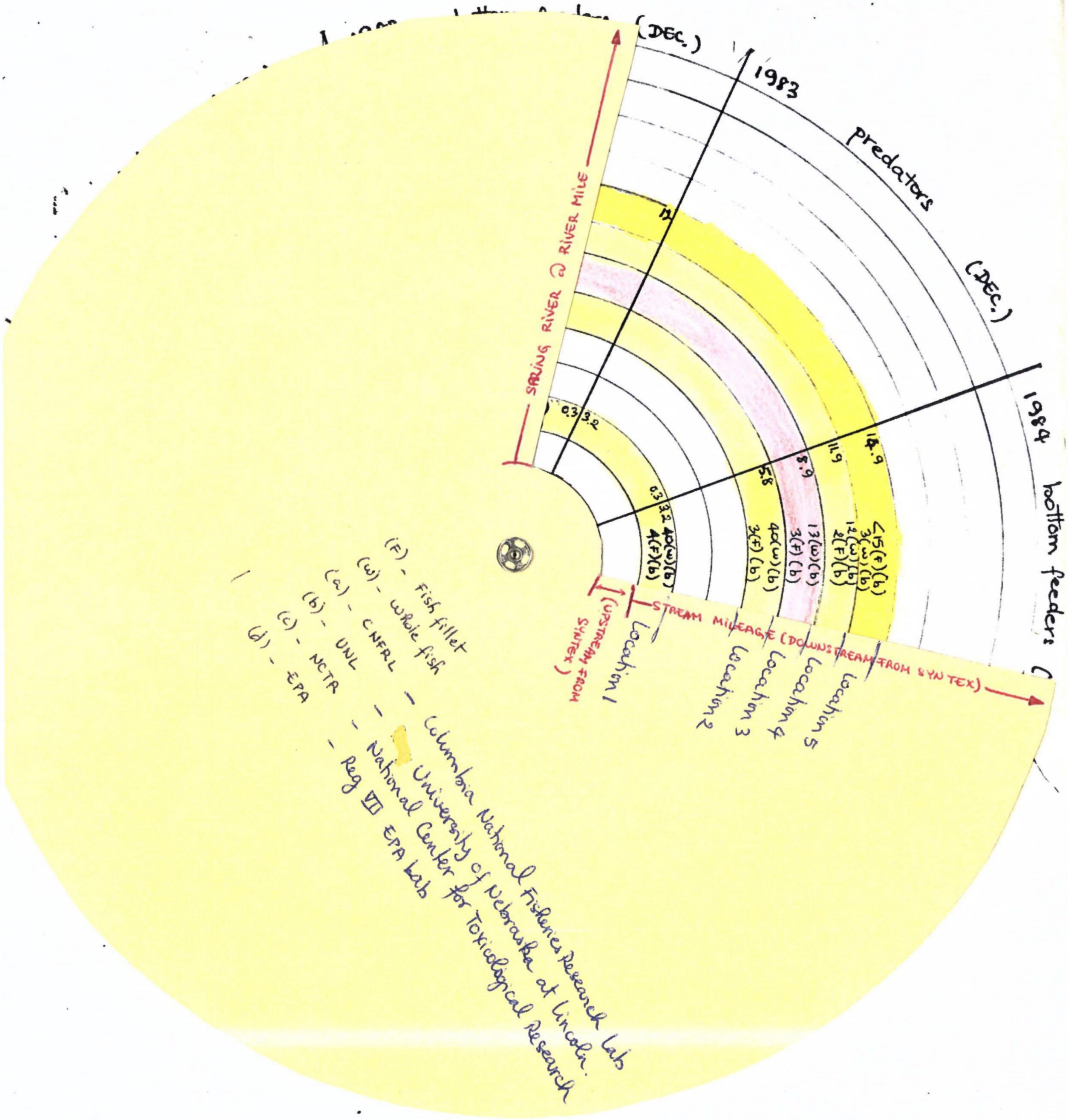

Table 2B : Spring River bottom feeders and predators pie chart

17-8502-16-36

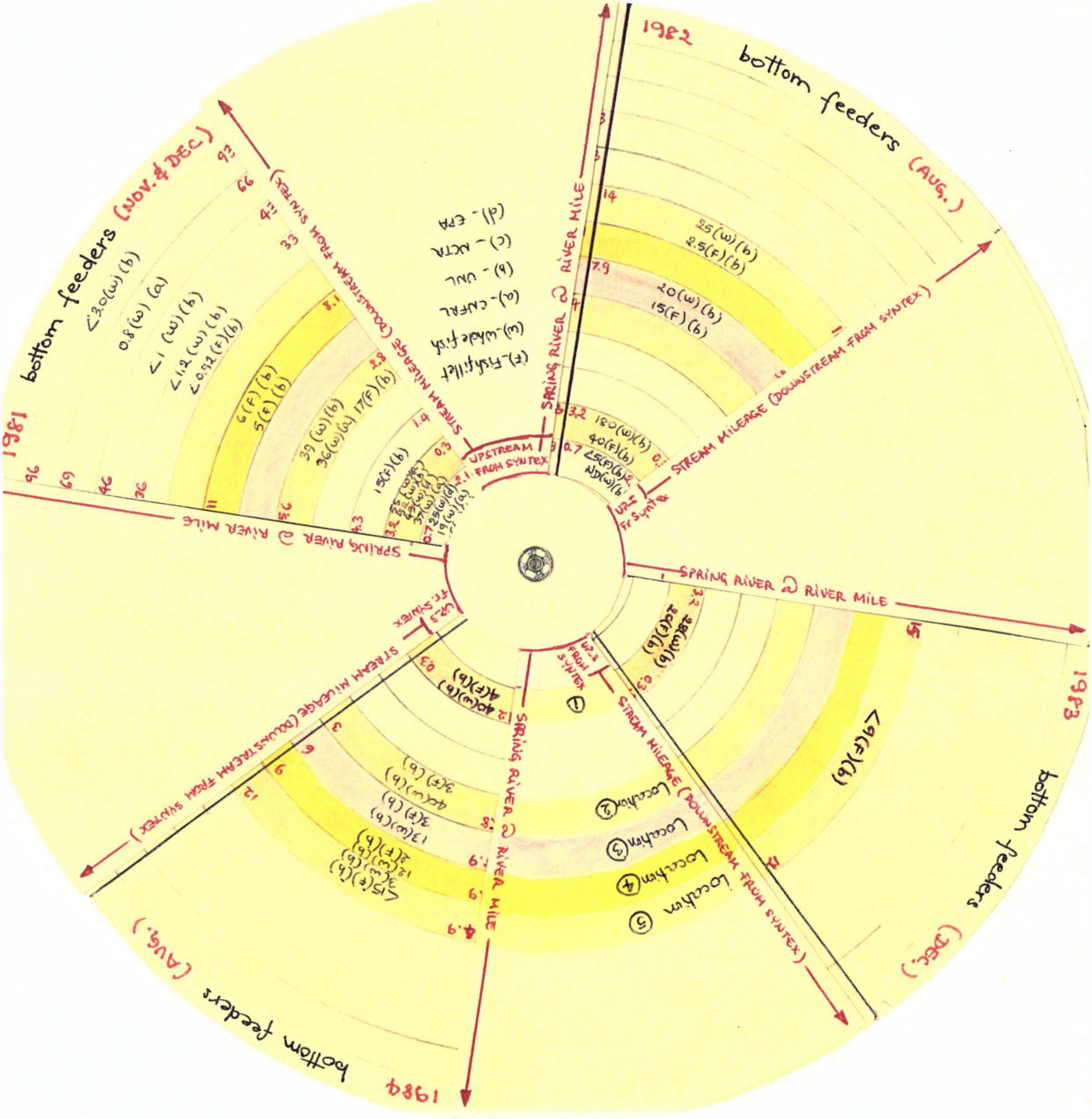

Table 2 A : Spring River bottom feeders and predators pie chart

17-8502-16-35

WESTON
DESIGNERS CONSULTANTS

BY __________ DATE __________ DIV __________ SHEET __________ OF __________
CHKD BY __________ DATE __________ DEPT __________ W.O. NO. __________
PROJECT __________
SUBJECT __________

location	1981		1982		1983		1984	
	(c) W	F	W	F	W	F	W	F
location 1 (0.3 miles)	55 52 45 37 (a) 47.25	—	180	40	28	20	40	4
location 2 (3 miles)	39 36 (a) 37.5	17	—	—	—	—	40	3
location 3 (6 miles)	—	—	20	15	—	—	13	3
location 4 (9 miles)	—	6 5 (b) 5.5	—	—	—	—	12	2
location 5 (12 miles	—	—	25	2.5	—	4.5 (b)	7.5 (b)	3

Table 3A: Spring River whole fish and fish fillet (bottom feeders) TCDD concentration (ppt)

a - Average value of TCDD concentration

b - ½ value of the detection limit.

c - W - whole fish

F - Fish fillet

WESTON DESIGNERS CONSULTANTS

BY______ DATE______ DIV______ SHEET______ OF______

CHKD BY______ DATE______ DEPT______ W.O. NO.______

PROJECT______

SUBJECT______

Location	1981		1982		1983		1984	
	(a) W	F	W	F	W	F	W	F
Location 1 (0.3 miles)	—	18	200	3	—	—	—	—
Location 2 (3 miles)	0.4	—	—	—	—	—	—	—
Location 3 (6 miles)	—	—	40	15	—	—	—	—
Location 4 (9 miles)	0.5	4	—	—	—	—	—	—
Location 5 (12 miles)	—	—	40	2	—	—	—	—

Table 3D Spring River whole fish and fish fillet (predators) TCDD concentration (ppt)

a - W: whole fish

F: Fish fillet

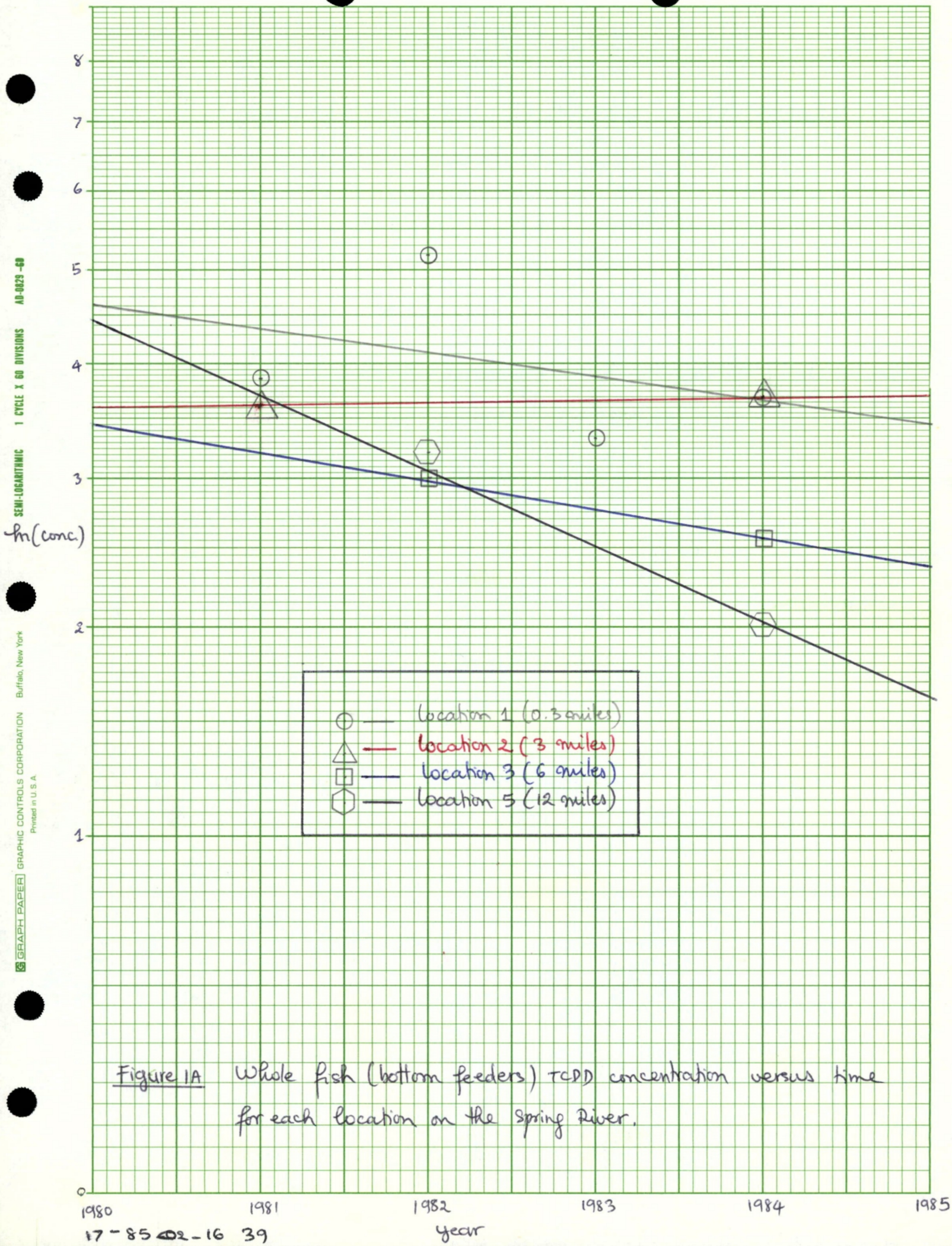

Figure 1A Whole fish (bottom feeders) TCDD concentration versus time for each location on the Spring River.

17-85-02-16 39

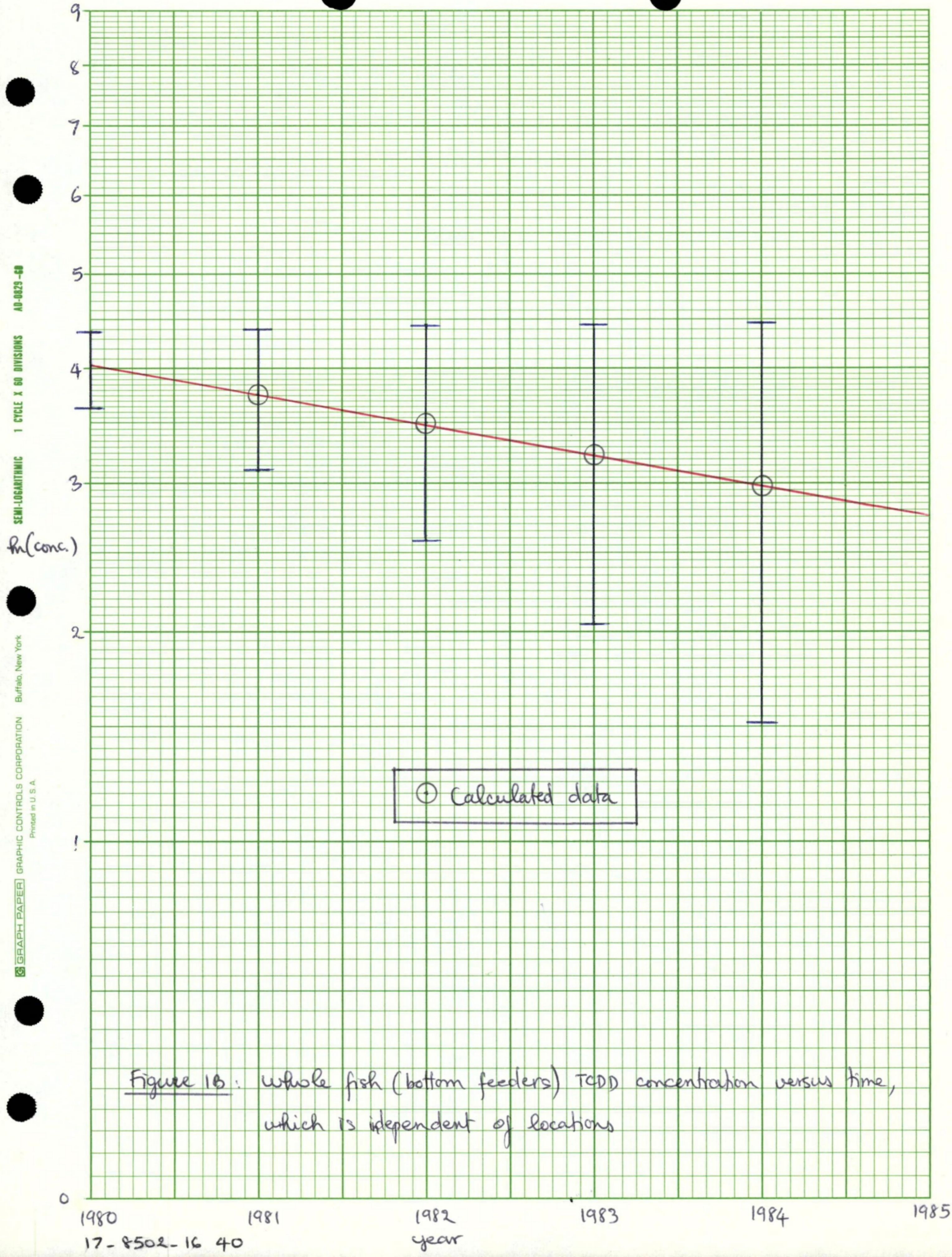

Figure 1B: whole fish (bottom feeders) TCDD concentration versus time, which is independent of locations

17-8502-16 40

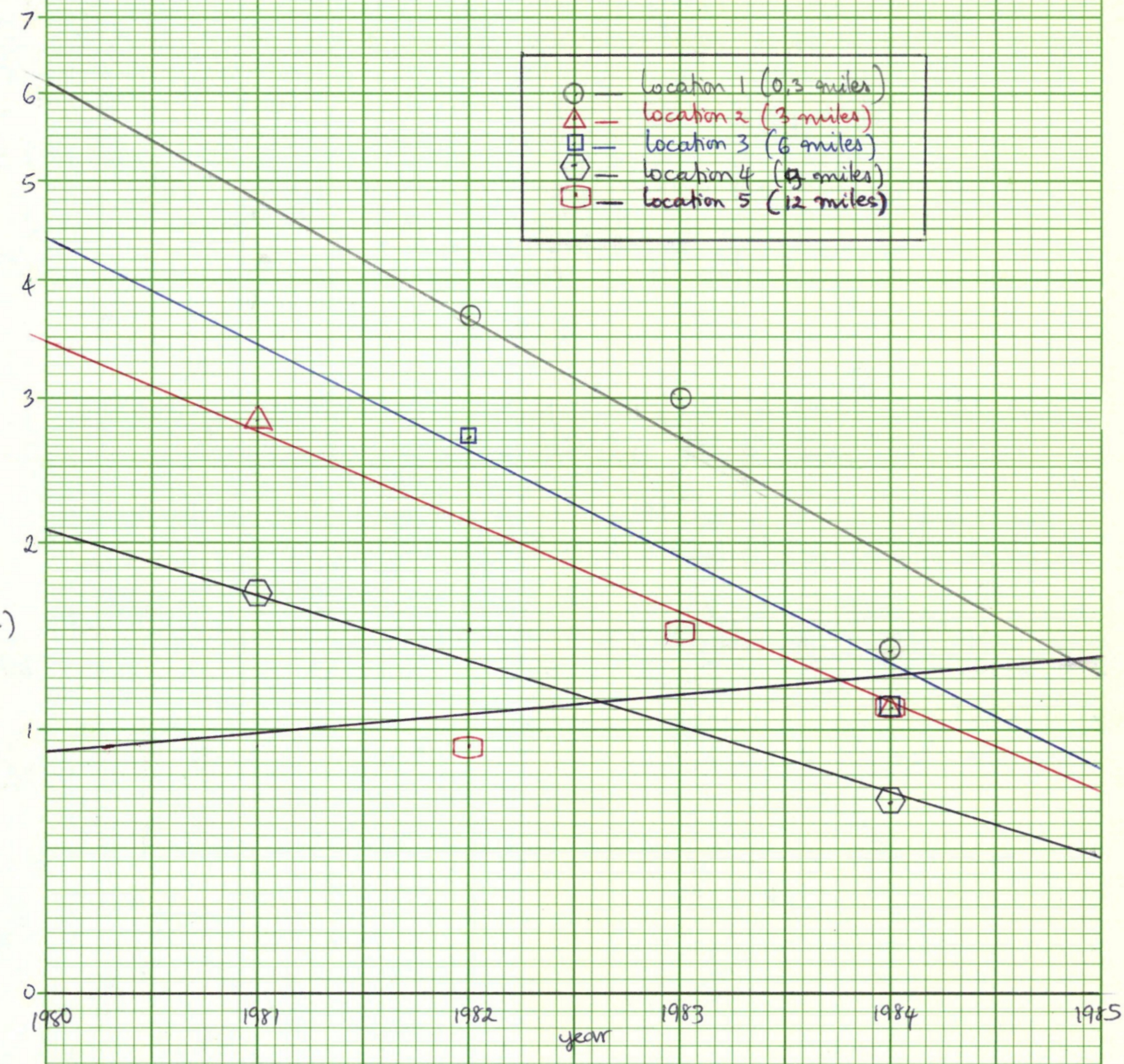

Figure 2A: fish fillet (bottom feeders) TCDD concentration versus time for each location on the spring River

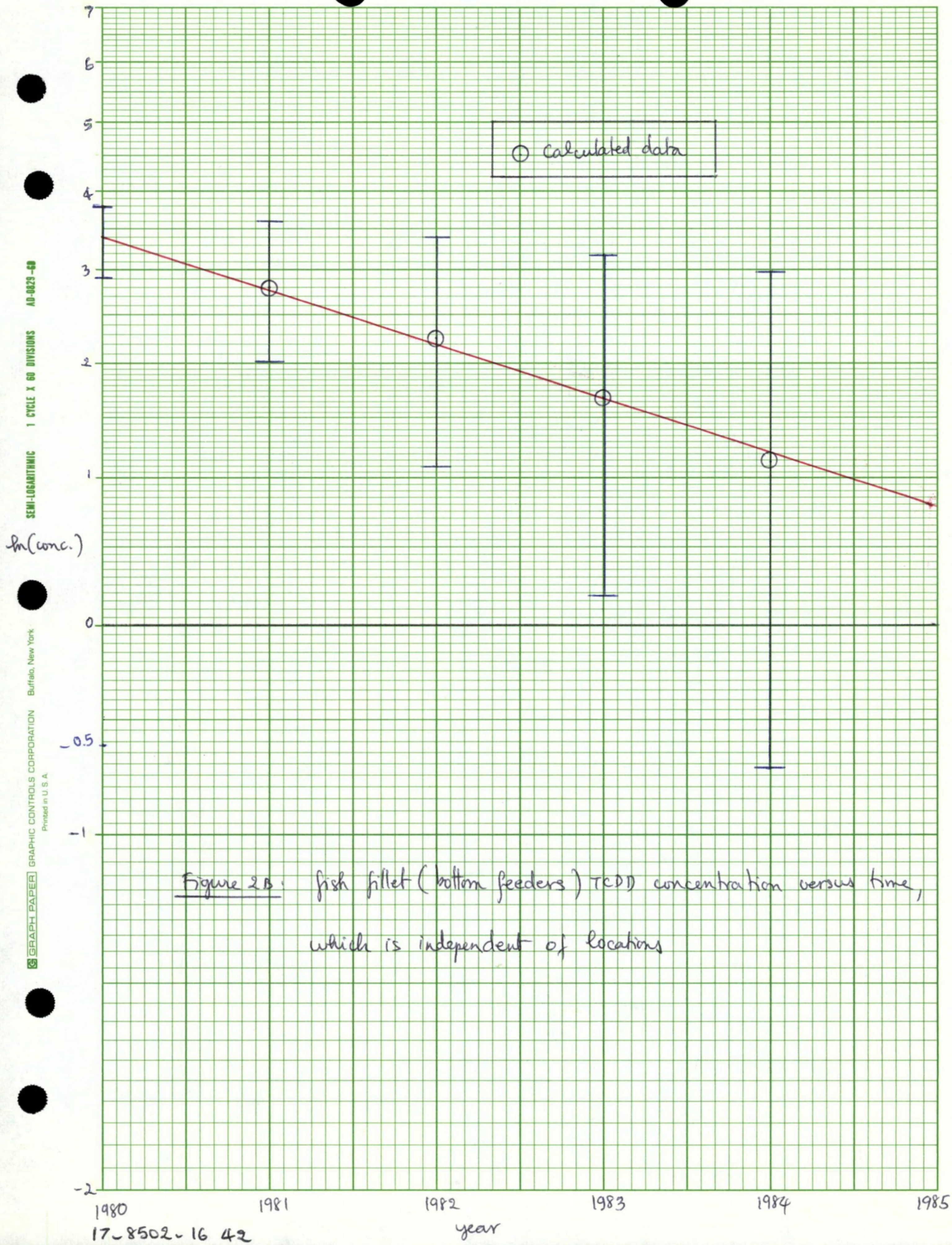

Figure 2B: fish fillet (bottom feeders) TCDD concentration versus time, which is independent of locations

17-8502-16 42

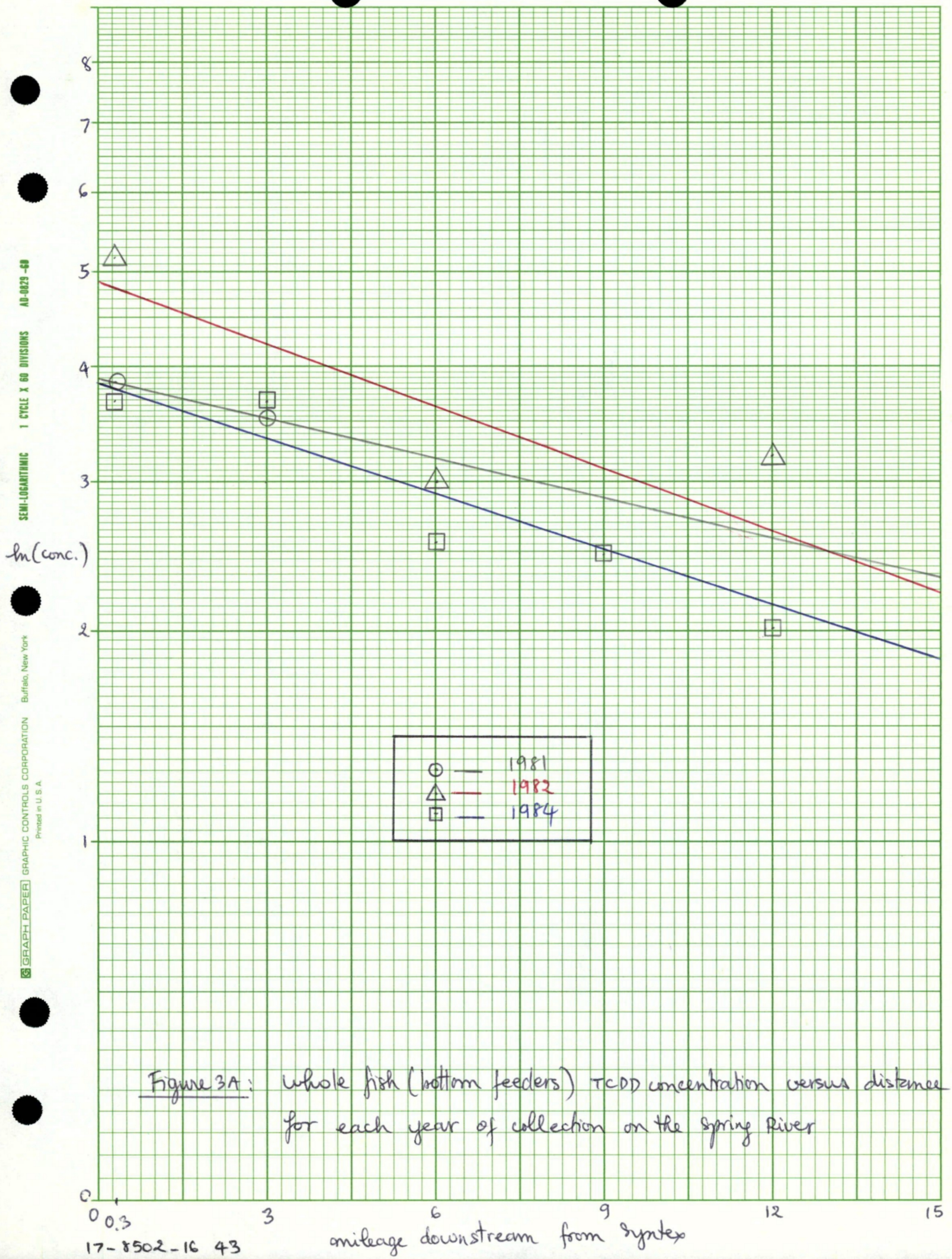

Figure 3A: whole fish (bottom feeders) TCDD concentration versus distance for each year of collection on the Spring River

17-8502-16 43

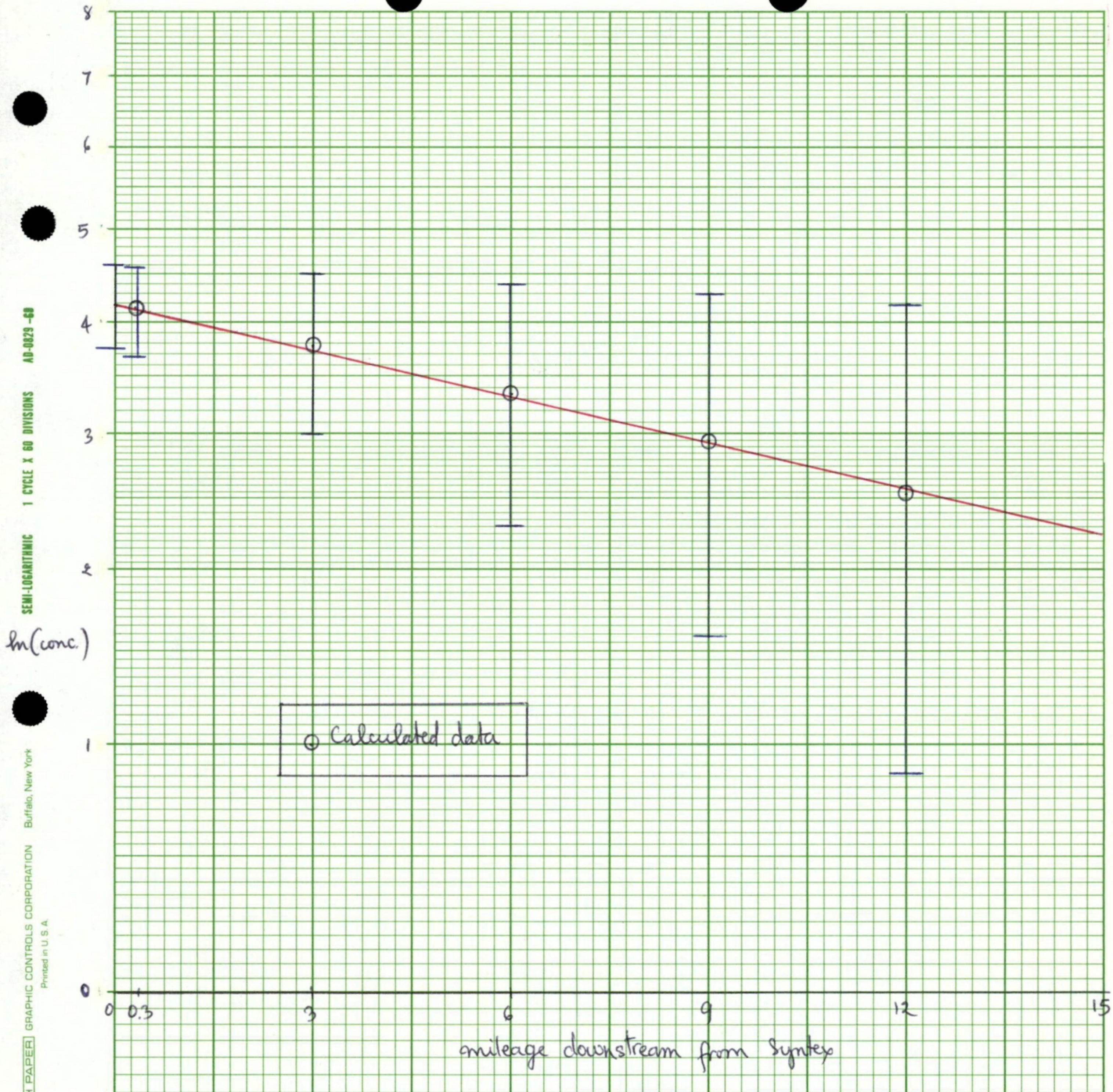

Figure 3B whole fish (bottom feeders) TCDD concentration versus distance, which is independent of time

17-8502-16 44

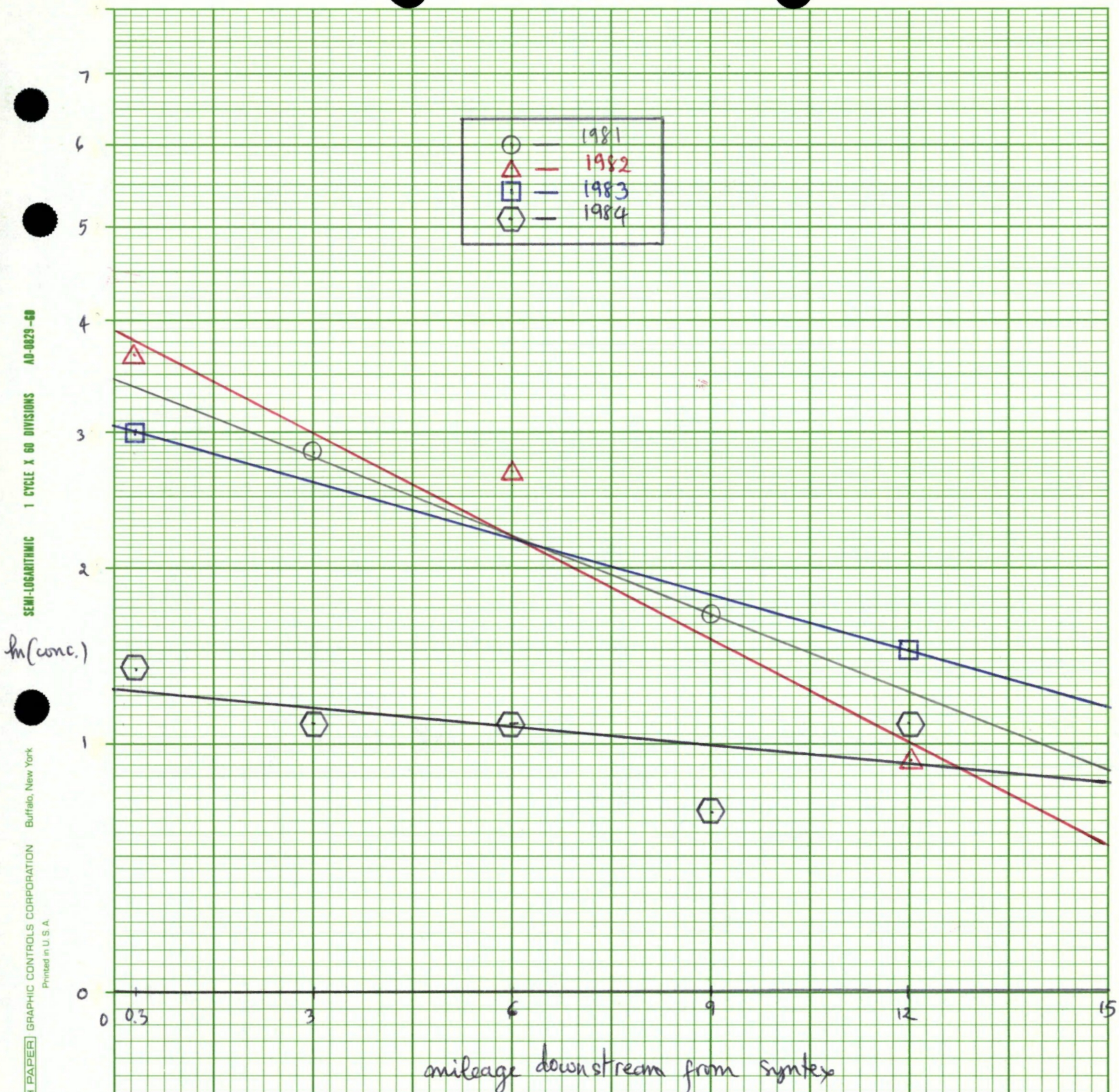

Figure 4A: fish fillet (bottom feeders) TCDD concentration versus distance for each year of collection on the Spring River

17-8502-16 45

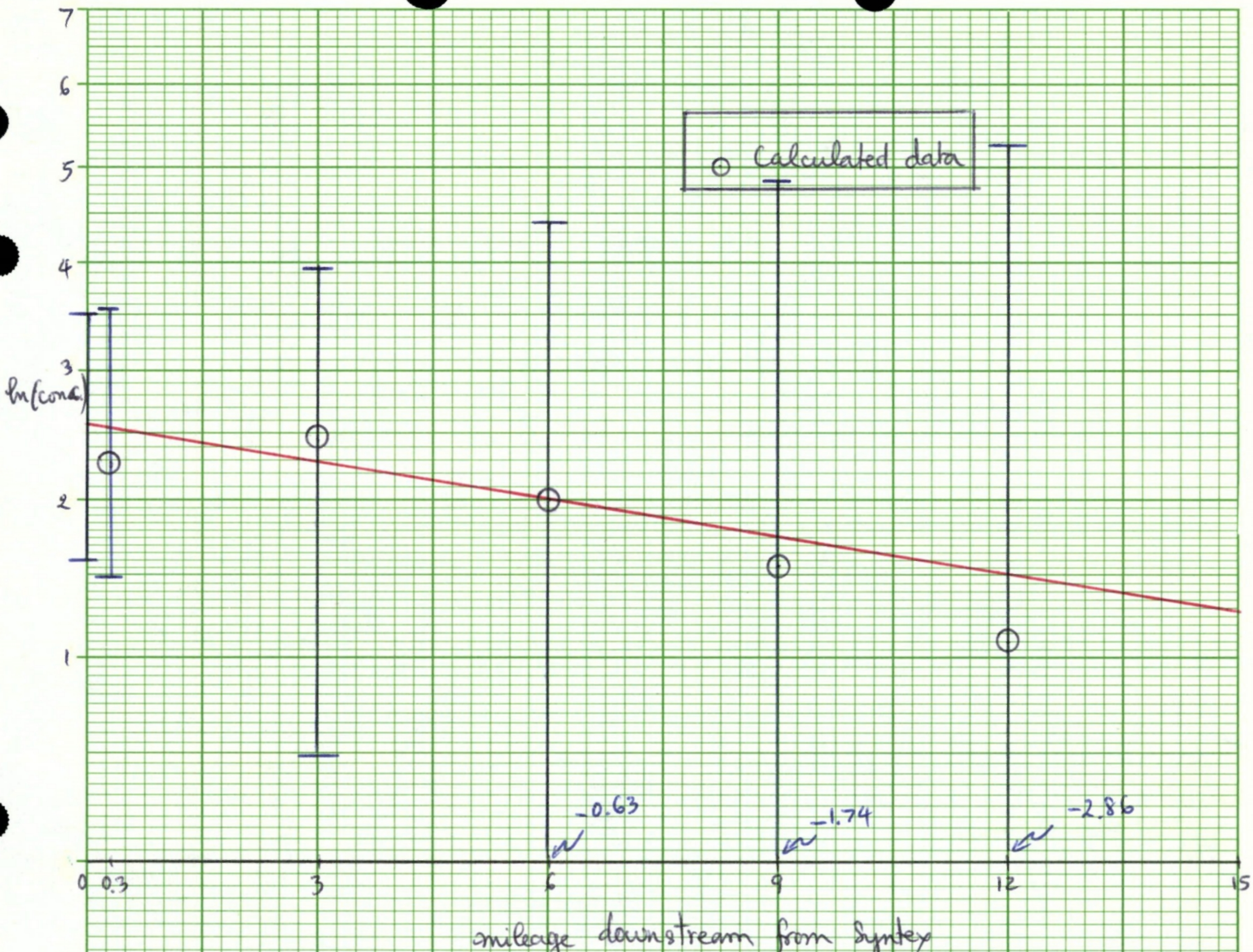

Figure 4B: fish fillet (bottom feeders) TCDD concentration versus distance, which is independent of time.

17-8502-16 46

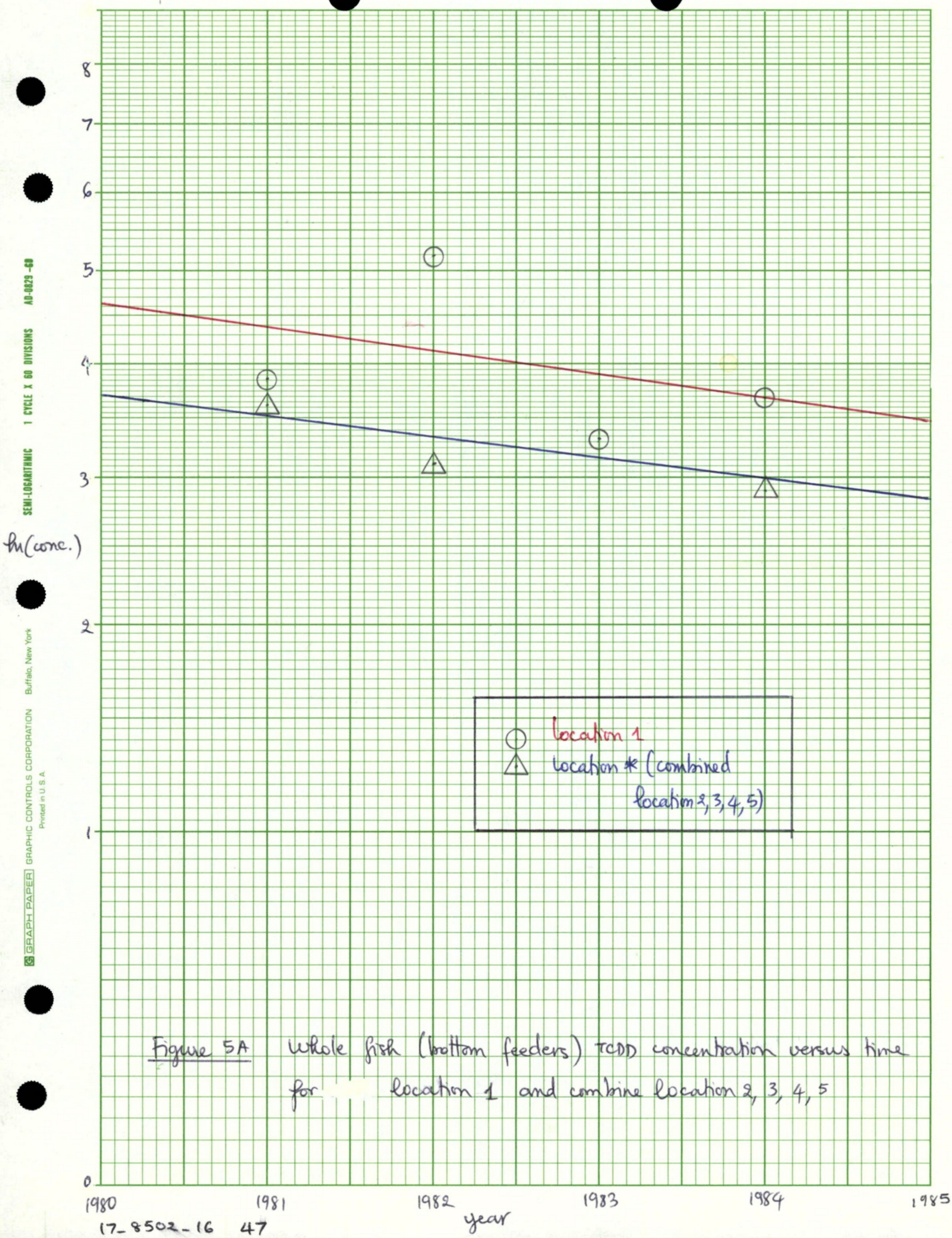

Figure 5A Whole fish (bottom feeders) TCDD concentration versus time for location 1 and combine location 2, 3, 4, 5

17_8502_16 47

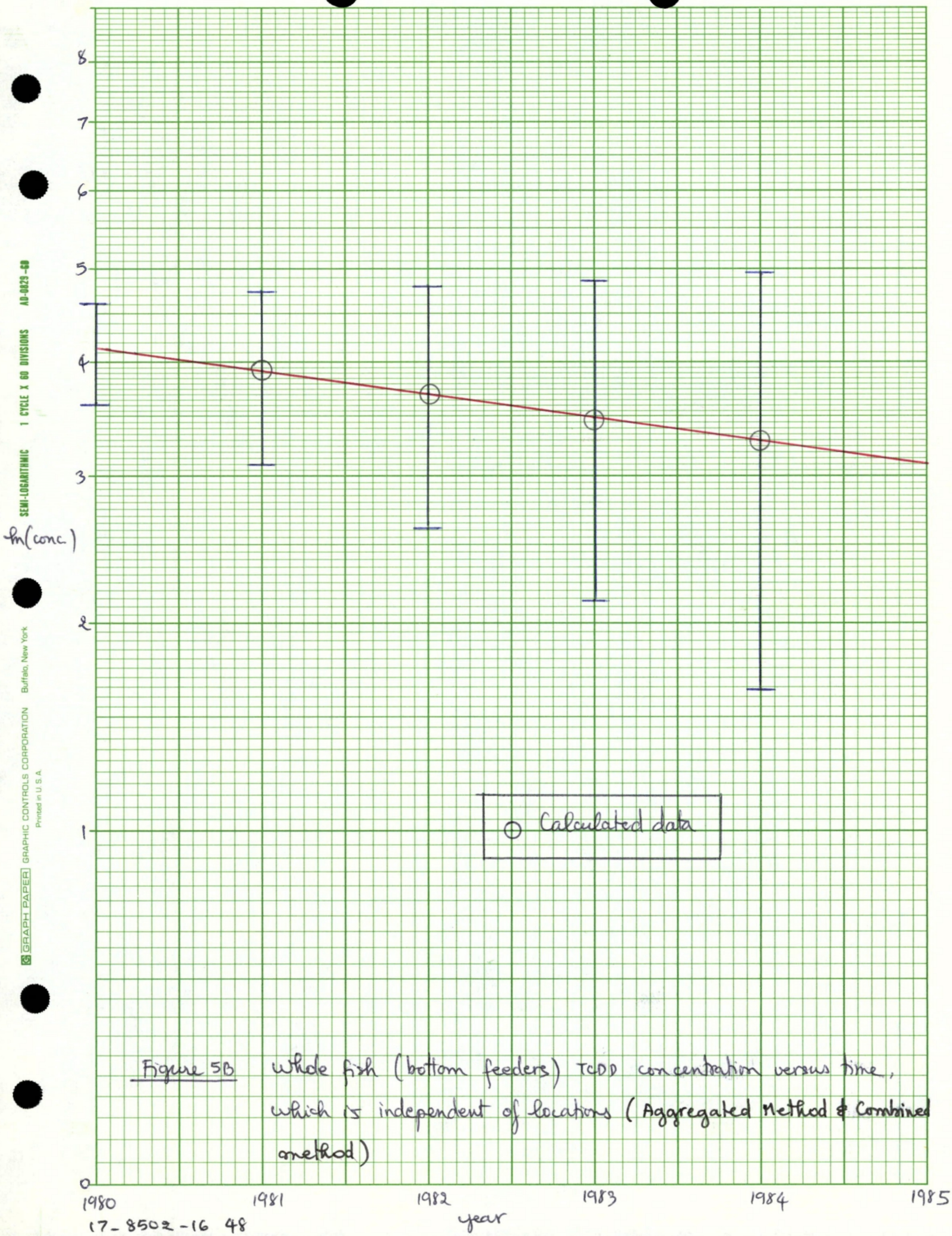

Figure 5B whole fish (bottom feeders) TCDD concentration versus time, which is independent of locations (Aggregated Method & Combined method)

17-8502-16 48

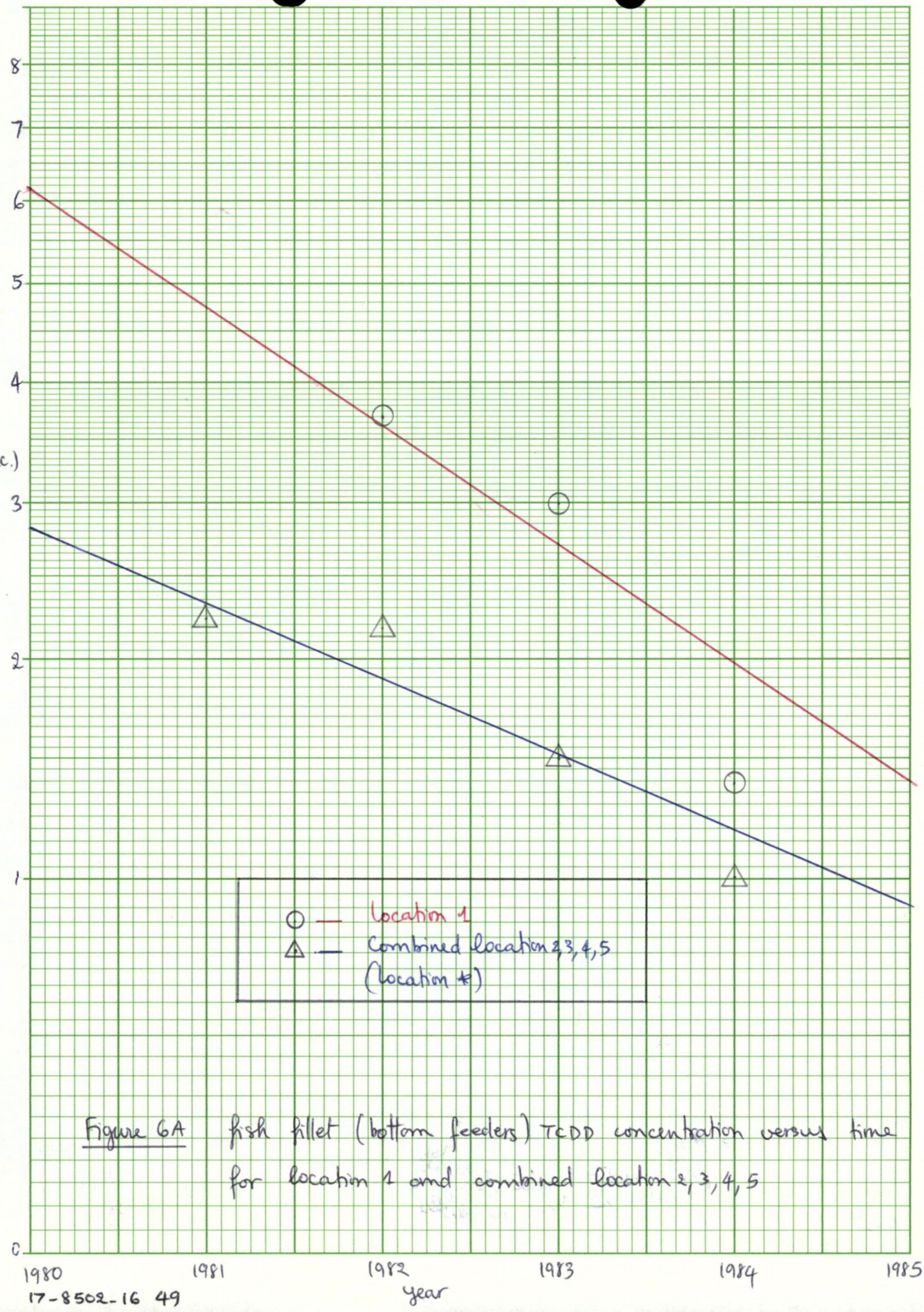

Figure 6A fish fillet (bottom feeders) TCDD concentration versus time for location 1 and combined location 2, 3, 4, 5

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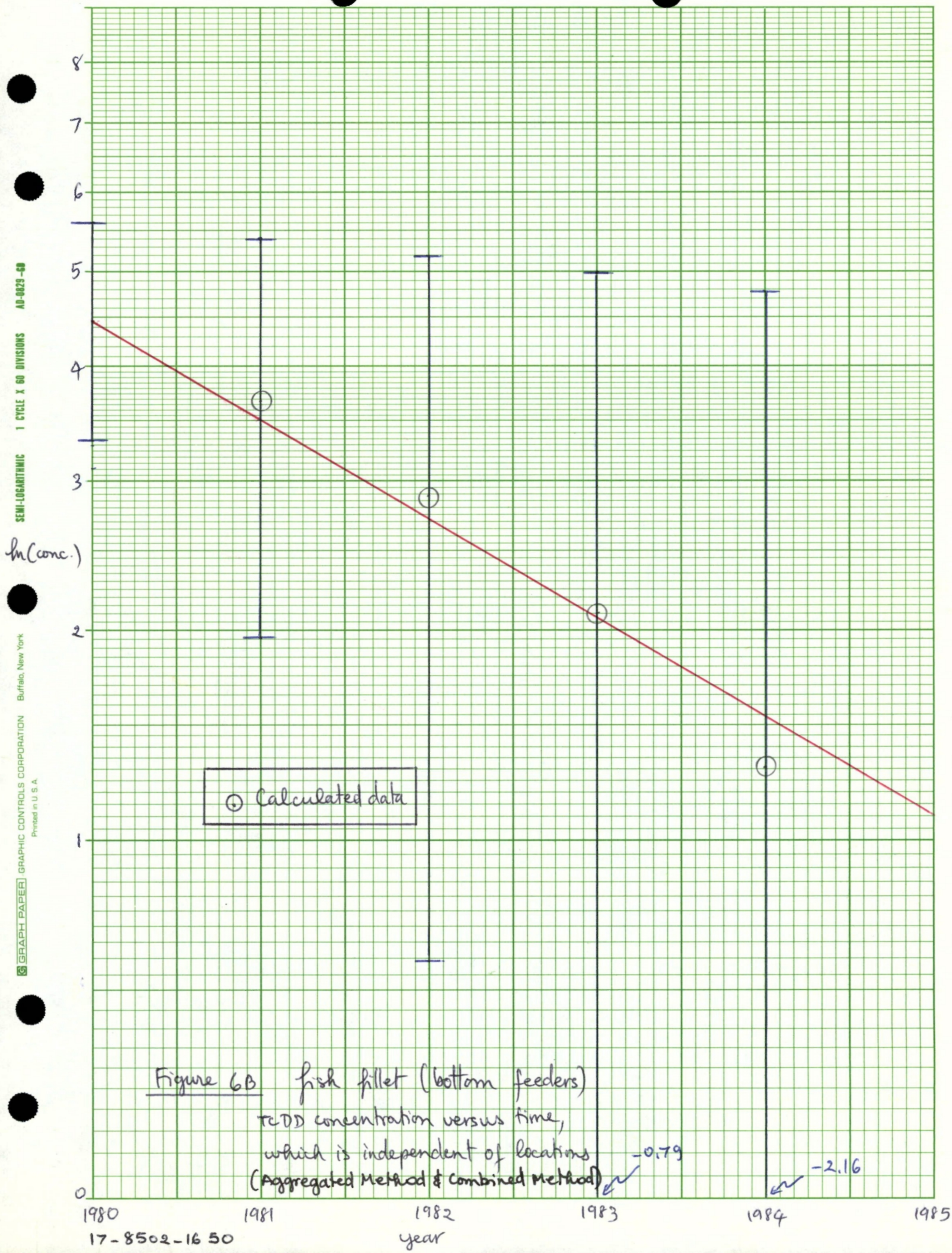

Figure 6B fish fillet (bottom feeders)
TCDD concentration versus time,
which is independent of locations
(Aggregated Method & Combined Method)

17-8502-1650

6.0 DISCUSSION

TCDD-adsorbed particulates in soil runoff accumulate in the sediments of water-courses, which then become the ultimate sinks. Therefore, sediment material becomes an effective and easily accessible monitoring tool for TCDD. Sediment material may also provide information about unknown TCDD sources as well as facilitate identification of contamination from known sites, since contaminants in sediment, unlike fish, cannot move upstream. Although, the sediment sampling efforts by the EPA in November 16, 1981 indicated that there was only one sample showing positive dioxin contamination of levels 12 ppt (refer to table 1), the rest of sampling efforts in 1981 and 1982 were not detected.

The analysis of stream sediments for TCDD appears to be a viable tool for determining the extent and distribution of TCDD contamination within the drainage area of a TCDD site. However, the problem of sediment relocation may confound the identification of the source of contamination. Wakeham and Farington (1980) reported that pollutant hydrocarbons may be transported great distances from the source of contamination and deposited in sediments of remote area. Furthermore, as mentioned early in the Spring River introduction section, the upper reaches of the stream are subject to flooding on a fairly regular basis. The first USGS gauging station on the Spring River is at LaRussell, Missouri, 33 miles downstream from Verona. Average annual daily flow rate at this station is 252 cubic feet per second (cfs). Minimum and maximum flow rates for the period of record (1947 to present) are 15,000 and 22,500 cfs, respectively.

Thus, while sediment samples may be the best method for identifying and mapping contamination, there are other factors that must be considered when using this parameter for monitoring purposes. The sediment statistical analysis was not analyzed due to the lack of data.

Bottom feeder data were chosen for the fish statistical analysis since there were more data points for bottom feeders than for predator species (refer to table 3A). Notice that in Table 3A, a one-half value of the detection limit of the assay will be assigned to all samples which fall below the detection limit of 15 ppt (i.e., as of table 3A, one-half values of the detection limits of the assay were assigned to the samples at location 5, 4.5 and 7.5 ppt in 1983 and 1984 respectively). The pie charts 2A and 2B were also established for the convenience of comparing TCDD levels of predators and/or bottom feeders within a year, or among years.

Significant errors in fish statistical analysis may arise from the effects of bioconcentration, bioaccumulation, and biomagnification factor (refer to 3.31.) as well as from the discrepancy of laboratory analytical method. The following assumptions were applied to the analysis in an effort to learn the extent of dioxin contamination on the Spring River.

- All fish samples were consistently collected (i.e., very similar in weight portion, age...) at same locations (i.e., 0.3, 3, 6, 9, 12 miles downstream from Syntex).

* All fish samples were consistently collected in same season each year (i.e., month of August).
* Laboratory analytical method for fish samples was consistent and performed by the same laboratory.

Fish sampling efforts from 1981 to 1984 have not produced enough data for the analysis (refer to Table 3B) due to the discrepancy of sampling collections (i.e., locations, time). As figure 1A indicated, there were only two (2) sampling data at location 2, location 3 and location 5, from 1981 to 1984. Figure 2A showed that there were only two (2) sampling data at location 2, from 1981 to 1984, as well as at location 3 and location 4. Figure 3A showed two (2) sampling data in 1981. Figure 4A showed two (2) sampling data in 1981 and in 1983.

In statistical analysis, the fewer the data points the greater significant errors yield. Linear regression was applied to obtain a straight line through massing points in the x-y coordinators (refer to section 3.4.1). The plot of 2 data points will yield a straight line with coefficient correlation of 1 or -1, which is not an efficient source for interpretation of the analysis. That could lead to large errors. In other words, the analysis based on the available data is not reliable. Furthermore, because of the lack of data, the Student's t distribution was applied for estimating significant intervals of slope (i.e., B1, B-2) and intercept values.

Two methods were applied for the Spring River fish analysis:

1. Analyze the combined data points of all locations (combined method), and
2. Analyze data points at location 1 and at aggregated remaining locations of concern (aggregated method) to learn the extent of dioxin contamination and the confidence among the data.

Figure 1B - whole fish (bottom feeders) TCDD concentration versus time which is independent of locations (combined method) - showed a significant decrease in the fish results with time (1981 to 1984). Its slope (B1) has a value of -0.26 ± 0.27 compared to that of figure 5B - whole fish (bottom feeders) TCDD concentration versus time which is independent of locations (aggregated method and combined method) which has a slope value of -0.21 ± 0.28. The difference in the slopes is approximately 20%. This indicated a reasonable distribution of whole fish data at each location, in term of data consistency.

Figure 2B - fish fillet (bottom feeders) TCDD concentration versus time, which is independent of locations (combined method) - showed a significant decrease in the fish results with time (1981 to 1984). Its slope (B1) has a value of -0.56 ± 0.36, compared to that of figure 6B - Fish fillet (bottom feeders) TCDD concentration versus time, which is independent of locations (aggregated method and combined method) - which has a slope value of -0.79 ± 0.56. The difference in the slopes is approximately 40%. This indicated a discrepancy in fish fillet data at each location, in term of data consistency.

Also, figure 5A (whole fish - location 1 - aggregated method) showed a significant variation in the fish results with time (1981 to 1984). Its slope has a value of -0.24 ± 1.77 (table 9) compared to that of figure 6A (fish fillet - location 1 - aggregated mehtod) which has a slope value of -1.15 ± 3.37 (table 10). Since the significant figures here are so large, the anti-logarithmic values will yield to a large amount of TCDD concentration in ppt.

Figure 5A (whole fish - aggregated location 2, 3,4,5 - aggregated method) showed a significant varation in the fish results with time (1981 to 1984). Its slope has a value of -0.22 ± 1.27. (Table 9) Also, figure 6A (fish fillet - aggregated location 2, 3,4,5 - aggregated method) showed a varation in the fish results with time (1981 to 1984). Its slope has a value of -0.44 ± 0.37 (Table 10).

The above significance led to the conclusion:

- Whole fish data have less variational degree than that of fish fillet data that probably due to the bio-factors.
- The combined method showed the tendency of TCDD concentration decreasing with time more significant than that of the aggregated method which has large values of significant figures.
- Aggregated method showed no significant increase nor decrease in the fish results at location 1 and neither at other aggregated location 2,3,4,5.

Figure 3B (whole fish (bottom feeders) TCDD concentration versus distance, which is independent of time - combined method) showed a significant decrease of fish results with distance. Its slope (B2) has a value of -0.14 $\pm$ 10.

Figure 4B (fish fillet (bottom feeders) TCDD concentration versus distance, which is independent of time - combined method) showed a significant variation of fish results with distance. Its slope (B2) has a value of -0.11 $\pm$ 0.26.

In summary, in the Spring River sediment study, another factor should be taken into consideration. During the transportation of contaminated sediment to downstream areas, a slow but steady dissolution of TCDD into water lowers the concentration of TCDD in the sediment (refer to 3.2.1).

Also, one can get an approximate idea of the probable flushing in the upper reaches of the basin (refer to 2.1.1 Spring River introduction). How many of these events actually inundated the upper reaches of the basin is unknown and local residents' memories of years of flood events are unreliable. However, the data (2.1.1) suggests that the system has been subjected to considerable flushing. Therefore, sediment sampling efforts at same locations each year are not necessary and it would not help for the Spring River contaminant study.

Fish study indicated that very limited conclusions can be made regarding the extent of migration. Suckers (bottom feeders) may travel 20 to 30 miles, and this would not be unusual for bass. Also, fish can be expected to move upstream during the spring to spawn. Concentrations of environmental contaminates in fish can be expected to increase during the spring and summer when they are the fattest.

Fish statistical analysis for the Spring River fish study cannot be reliable since it has a very few sampling data and a discrepancy of data collections. However, regardless of these factors, the analysis indicated that whole fish data were more consistent and reliable than that of fish fillets. Aggregated method (analyze fish data at location 1 and at combined location 2,3,4,5) showed no significant increase nor decrease of dioxin contamination levels with time at either locations. Combined method (analyze all fish data at combined location 1,2,3,4,5) showed a significant decrease of dioxin contamination levels with time as well as with distance. However, the reliability of this method is in question and reliable person(s) should be considered for the future Spring River fish study.

7.0 - CONCLUSION

Based upon the water discharge rates in the Spring River at LaRussel, approximately 33 miles downstream from Verona (annual average daily flow is 252 cfs); sediment samples are not necessarily collected at the same locations in each year, since the Spring River system has been subjected to considerable "flushing".

Fish statistical analysis for the Spring River fish study cannot be reliable since it has a very few sampling data and also due to the discrepancy of data collections and the analytical methods. Also, bio-factors in the fish study were not taken into consideration in the analysis. However, in an effort to learn the extent of dioxin contamination on the Spring River, the combined method (combine fish data of all locations) showed significant decrease in the fish results with time as well as with distance. The aggregated method (analyze fish data at location 1 and at the aggregated location 2,3,4,5) showed no significant decrease nor increase in the fish results with time at location 1 and showed neither at the aggregated location 2,3,4,5. Furthermore, whole fish data were more reliable and consistent than that of fish fillets.

Further fish sampling and analysis is needed for the Spring River fish study. Fish sampling and analytical efforts should fall into the following categories which are similar to the 1984 fish samples and analysis.

* All fish samples should be collected consistently at same locaions (i.e., 0.3, 3,6,9, 12 miles downstream from Syntex) or as near thereto as access to the

river permits.

* All fish samples should be collected consistently at same season each year (i.e., month of August).
* Laboratory analytical method for fish samples should be consistent and performed by same laboratory.

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9.0 - APPENDIX

9.1. locations (4.1.4)

It was intended that the samples be taken at the following sampling locations (or as near thereto as access to the river permits):

(1). location 1 - 0.3 miles downstream from the Facility.

(2) location 2 - 3 miles downstream from the Facility.

(3) location 3 - 6 miles downstream from the Facility.

(4) location 4 - 9 miles downstream from the Facility.

(5) location 5 - 12 miles downstream from the facility.

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location	1981		1982		1983		1984	
	(a) W	F	W	F	W	F	W	F
location 1 (0.3 miles)	3.86	—	5.19	3.69	3.33	3.00	3.69	1.39
location 2 (3 miles)	3.62	2.84	—	—	—	—	3.69	1.10
location 3 (6 miles)	—	—	3.00	2.71	—	—	2.56	1.10
location 4 (9 miles)	—	1.70	—	—	—	—	2.48	0.69
location 5 (12 miles)	—	—	3.22	0.92	—	1.50	2.01	1.10

Table 3B : logarithmic values of TCDD concentration of whole fish and fish fillet of the Spring River.

a - W - whole fish
F - Fish fillet } bottom feeders

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Location	1981		1982		1983		1984	
	W	F	W	F	W	F	W	F
Location 1	3.86	–	5.19	3.69	3.33	3.00	3.69	1.39
Combined Location 2,3,4,5	3.62	2.24	3.11	2.17	–	1.50	2.90	1.01

Table 3c logarithmic values of TCDD concentration of whole fish and fish fillet for location 1 and combined location 2, 3, 4, 5

a - W - whole fish } bottom feeders
F - Fish fillet }

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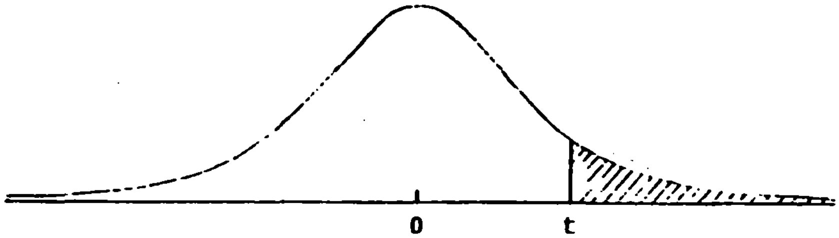

Degrees of freedom	0.005	0.01	0.025	0.05	0.1	0.25	0.35	0.45
	Probability of observing a deviation greater than t is:							
1	63.657	31.821	12.706	6.314	3.078	1.000	0.510	0.158
2	9.925	6.965	4.303	2.920	1.886	0.816	0.445	0.142
3	5.841	4.541	3.182	2.353	1.638	0.765	0.424	0.137
4	4.604	3.747	2.776	2.132	1.533	0.741	0.414	0.134
5	4.032	3.365	2.571	2.015	1.476	0.727	0.408	0.132
6	3.707	3.143	2.447	1.943	1.440	0.718	0.404	0.131
7	3.499	2.998	2.365	1.895	1.415	0.711	0.402	0.130
8	3.355	2.896	2.306	1.860	1.397	0.706	0.399	0.130
9	3.250	2.821	2.262	1.833	1.383	0.703	0.398	0.129
10	3.169	2.764	2.228	1.812	1.372	0.700	0.397	0.129
11	3.106	2.718	2.201	1.796	1.363	0.697	0.396	0.129
12	3.055	2.681	2.179	1.782	1.356	0.695	0.395	0.128
13	3.012	2.650	2.160	1.771	1.350	0.694	0.394	0.128
14	2.977	2.624	2.145	1.761	1.345	0.692	0.393	0.128
15	2.947	2.602	2.131	1.753	1.341	0.691	0.393	0.128
16	2.921	2.583	2.120	1.746	1.337	0.690	0.392	0.128
17	2.898	2.567	2.110	1.740	1.333	0.689	0.392	0.128
18	2.878	2.552	2.101	1.734	1.330	0.688	0.392	0.127
19	2.861	2.539	2.093	1.729	1.328	0.688	0.391	0.127
20	2.845	2.528	2.086	1.725	1.325	0.687	0.391	0.127
21	2.831	2.518	2.080	1.721	1.323	0.686	0.391	0.127
22	2.819	2.508	2.074	1.717	1.321	0.686	0.390	0.127
23	2.807	2.500	2.069	1.714	1.319	0.685	0.390	0.127
24	2.797	2.492	2.064	1.711	1.318	0.685	0.390	0.127
25	2.787	2.485	2.060	1.708	1.316	0.684	0.390	0.127
26	2.779	2.479	2.056	1.706	1.315	0.684	0.390	0.127
27	2.771	2.473	2.052	1.703	1.314	0.684	0.389	0.127
28	2.763	2.467	2.048	1.701	1.313	0.683	0.389	0.127
29	2.756	2.462	2.045	1.699	1.311	0.683	0.389	0.127
30	2.750	2.457	2.042	1.697	1.310	0.683	0.389	0.127
∞	2.576	2.326	1.960	1.645	1.282	0.674	0.385	0.126

Table 4: Student's t distribution chart

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9.2 Calculations

The following calculations were based on the assumptions of:

a. All fish samples were consistently collected (i.e., weight portion, age) at same locations (i.e, 0.3, 6, 9, 12 miles downstream from Syntex).

b. All fish samples were consistently collected at same season each year (i.e., month of August).

c. laboratory analytical method for fish samples was consistent and performed by the same laboratory.

9.2.1. Plot a graph of whole fish (bottom feeders) TCDD concentration versus time for each location on the Spring River, using linear least squares method (figure 1A).

Step(1). * Data points (table 3B)

ex. table 3B @ location 1

	1981	1982	1983	1984
	W	W	W	W
location 1	3.86	5.19	3.33	3.69

* Using linear least squares method (3.4.1.)

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$n = 4$

$$\bar{x} = \frac{1+2+3+4}{4} = 2.50$$

$$\bar{y} = \frac{3.86 + 5.19 + 3.33 + 3.69}{4} = 4.02$$

$$\Sigma(x)^2 = (1)^2 + (2)^2 + (3)^2 + (4)^2 = 30$$

$$\Sigma(y)^2 = (3.86)^2 + (5.19)^2 + (3.33)^2 + (3.69)^2 = 69.54$$

$$(\Sigma x)^2 = (1+2+3+4)^2 = 100$$

$$(\Sigma y)^2 = (3.86 + 5.19 + 3.33 + 3.69)^2 = 258.25$$

$$\Sigma x = 10$$

$$\Sigma y = 16.07$$

$$\Sigma xy = \{(1)(3.86)\} + \{(2)(5.19)\} + \{(3)(3.33)\} + \{(4)(3.69)\}$$

$$= 38.99$$

Eq. (5), (6), (7) @ 3.4.1

$$S_{xx} = \Sigma x^2 - \frac{(\Sigma x)^2}{n} = 30 - \frac{100}{4} = 5$$

$$S_{yy} = \Sigma y^2 - \frac{(\Sigma y)^2}{n} = 69.54 - \frac{258.25}{4} = 4.98$$

$$S_{xy} = \Sigma xy - \frac{\Sigma x \cdot \Sigma y}{n} = 38.99 - \frac{(10)(16.07)}{4} = -1.18$$

Eq. (2), (3), (4) @ 3.4.1.

Equation of line ($y = mx + b$) for TCDD concentration versus time at location 1.

where:

$$m = \frac{S_{xy}}{S_{xx}} = \frac{-1.18}{5} = -0.24$$

$$b = \bar{y} - m\bar{x} = 4.02 - (-0.24)(2.50) = 4.61$$

$$r = \frac{S_{xy}}{\sqrt{S_{xx} \cdot S_{yy}}} = \frac{-1.18}{\sqrt{(5) \cdot (4.98)}} = -0.3767$$

Similarly,

Location 1 (1)	Location 2 (2)	Location 3 (3)	Location 4 (4)	Location 5 (5)
$\ln y = -0.24T + 4.61$	$\ln y = 0.02T + 3.60$	$\ln y = -0.22T + 3.44$	—	$\ln y = -0.61T + 4.43$
$r = -0.3767$	$r = 1.000$	$r = -1.000$		$r = -1.000$

<u>Step(2)</u> Use the above equations (1, 2, 3, 5), calculate the data points for each location ~~at~~ in each year.

<u>ex</u>: eq. (1)

$$\ln y = -0.24T + 4.61$$

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for $T = 1$ (1981) $\Rightarrow$ $\ln y = -0.24(1) + 4.61 = 4.37$

$T = 2$ (1982) $\Rightarrow$ $\ln y = 4.14$

$T = 3$ (1983) $\Rightarrow$ $\ln y = 3.90$

$T = 4$ (1984) $\Rightarrow$ $\ln y = 3.66$

Similarly,

	1981	1982	1983	1984
	4.37 (eq.1)	4.14 (eq.1)	3.90 (eq.1)	3.66 (eq.1)
	3.62 (eq.2)	3.64 (eq.2)	3.66 (eq.2)	3.68 (eq.2)
	3.22 (eq.3)	3.00 (eq.3)	2.78 (eq.3)	2.56 (eq.3)
	3.83 (eq.5)	3.22 (eq.5)	2.62 (eq.5)	2.01 (eq.5)
Average:	3.76	3.50	3.24	2.98

Step(3) From the above average values, plot a graph of whole fish (bottom feeders) TCDD concentration versus time (1981, 1982, 1983, 1984), ~~which is independent of time~~ (figure 1B), using linear least squares method. (3.4.1.)

$$\boxed{\begin{aligned} \ln y &= -0.26T + 4.02 \\ r &= -1.000 \end{aligned}}$$

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Step (4) Calculate the confidence interval based on Student's t distribution, using 95% confidence limits on slope and intercept values (3.4.2) for the above equation.

- Data points from 9.2.1. (2)

$N = 16$

- $\ln y = -0.26T + 4.02$ (9.2.1. (3))

Eq. 10 @ 3.4.2 – Calculate s-value

$$(y - mx - b)^2$$

ex: 9.2.1. (2) @ 1981 (T=1)

$$\{4.37 - (-0.26)(1) - 4.02\}^2 = 0.3721$$

$$\{3.62 - (-0.26)(1) - 4.02\}^2 = 0.0196$$

$$\{3.22 - (-0.26)(1) - 4.02\}^2 = 0.2916$$

$$\{3.83 - (-0.26)(1) - 4.02\}^2 = 0.0049$$

Similarly,

	1981	1982	1983	1984
$(y-mx-b)^2$	0.3721	0.3969	0.4225	0.4489
	0.0196	0.0190	0.1764	0.4900
	0.2916	0.2500	0.5184	0.1764
	0.0049	0.0784	0.7744	0.9409

Eq. 10 @ 3.4.2

$$s^2 = \frac{1}{N-2} \sum (y - mx - b)^2$$

$$= \frac{1}{16-2} (5.3801) = 0.3844$$

$$s = 0.6200$$

Table 4 with 14 degrees of freedom and $P = 0.025$

$$t = 2.145$$

Eq. 8 @ 3.4.2.

$$\Sigma(x)^2 = (1)^2 + (2)^2 + (3)^2 + (4)^2 = 30$$

$$(\Sigma x)^2 = (1+2+3+4)^2 = 100$$

$$\mu = m \pm t.\, s\sqrt{\frac{N}{N\Sigma(x)^2 - (\Sigma x)^2}}$$

$$= -0.26 \pm (2.145)(0.6200)\sqrt{\frac{16}{16(30) - 100}}$$

$$\boxed{\mu = -0.26 \pm 0.27}$$

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Eq. 9 @ 3.4.2

$$\beta = b \pm t.s \sqrt{\frac{\Sigma (x)^2}{N\Sigma(x)^2 - (\Sigma x)^2}}$$

$$= 4.02 \pm (2.145)(0.6200) \sqrt{\frac{30}{16(30) - 100}}$$

$$\boxed{\beta = 4.02 \pm 0.37}$$

9.2.2. Plot a graph of fish fillet (bottom feeders) TCDD concentration versus time for each location using linear least squares method (figure 2A)

Apply the similar method (9.2.1.(1),(2),(3),(4).)

<u>Step(1)</u> data points (table 3B)

Location 1(1)	Location 2(2)	location 3(3)	location 4(4)	location 5(5)
$\ln y = -1.15T + 6.14$	$\ln y = -0.59T + 3.42$	$\ln y = -0.81T + 4.32$	$\ln y = -0.34T + 2.04$	$\ln y = 0.09T + 0.09$
$r = -0.9744$	$r = -1.000$	$r = -1.000$	$r = -1.000$	$r = 0.3032$

Step(2) Based on the above equations(1, 2, 3, 4, 5), calculate data points for each location in each year.

	1981	1982	1983	1984
	4.99 (eq.1)	3.84 (eq.1)	2.69 (eq.1)	1.54 (eq.1)
	2.83 (eq.2)	2.24 (eq.2)	1.65 (eq.2)	1.06 (eq.2)
	3.52 (eq.3)	2.71 (eq.3)	1.91 (eq.3)	1.10 (eq.3)
	1.70 (eq.4)	1.36 (eq.4)	1.02 (eq.4)	0.68 (eq.4)
	0.99 (eq.5)	1.08 (eq.5)	1.17 (eq.5)	1.26 (eq.5)
Average:	2.80	2.25	1.69	1.13

Step(3) From the above average values (9.2.2.(2)), plot a graph of fish fillet (bottom feeders) TCDD concentration versus time, which is independent of time (figure 2B) using linear least squares method.

$$\boxed{\begin{array}{l} \ln y = -0.56T + 3.36 \\ r = -1.000 \end{array}}$$

Step (4) calculated the confidence interval based on Student's t distribution, using 95% confidence limits on slope and intercept values of the above equation [9.2.2.(3)]

From 9.2.2. (2).

$N = 20 \Rightarrow$ 18 degrees of freedom

$P = 0.025$

$t = 2.101$ (table 4)

$S = 0.8454$

$$\boxed{\begin{aligned} \mu &= -0.56 \pm 0.36 \\ \beta &= 3.36 \pm 0.43 \end{aligned}}$$

9.2.3. Plot a graph of whole fish (bottom feeders) TCDD concentration versus distance for each year of sampling collection (figure 3A), using linear least squares method Apply the similar method [9.2.1. (1), (2), (3), (4)].

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Step (1) data points (table 3B)

1981 (81)	1982 (82)	1983 (83)	1984 (84)
$\ln y = -0.09X + 3.89$	$\ln y = -0.17X + 4.82$	—	$\ln y = -0.16X + 3.83$
$r = -1.000$	$r = -0.8082$		$r = -0.9486$

Step (2) Use the above equations (81, 82, 84), calculate the data points for each year at each location.

	Location 1	Location 2	Location 3	Location 4	Location 5
	3.86 (eq. 81)	3.62 (eq. 81)	3.35 (eq. 81)	3.09 (eq. 81)	2.82 (eq. 81)
	4.77 (eq. 82)	4.32 (eq. 82)	3.82 (eq. 82)	3.32 (eq. 82)	2.82 (eq. 82)
	3.78 (eq. 84)	3.36 (eq. 84)	2.89 (eq. 84)	2.43 (eq. 84)	1.96 (eq. 84)
Average:	4.14	3.77	3.35	2.95	2.53

Step (3) From the above average values, plot a graph of whole fish (bottom feeders) TCDD concentration versus distance, which is independent of time (figure 3B), using linear least squares method.

$$\boxed{\begin{aligned} \ln y &= -0.14X + 4.18 \\ r &= -1.000 \end{aligned}}$$

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Step (4) Calculate the confidence interval based on Student's t distribution, using 95% confidence limits on slope and intercept values.

From 9.2.3.(2).

$N = 15 \Rightarrow 13$ degrees of freedom.

$P = 0.025$

$t = 2.160$ (table 4)

$s = 0.6851$

$$\boxed{\begin{aligned} \mu &= -0.14 \pm 0.10 \\ \beta &= 4.18 \pm 0.43 \end{aligned}}$$

9.2.4 Plot a graph of fish fillet (bottom feeders) TCDD concentration versus distance for each year of sampling collection (figure 4A), using linear least squares method.

Apply the similar method [9.2.1. (1), (2), (3), (4)]

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Step (1) data (table 3B)

1981 (81)	1982 (82)	1983 (83)	1984 (84)
$\ln y = -0.19X + 3.41$	$\ln y = -0.24X + 3.89$	$\ln y = -0.13X + 3.04$	$\ln y = -0.04X + 1.28$
$r = -1.000$	$r = -0.9884$	$r = -1.000$	$r = 0.6194$

Step (2) Use the above equations (81, 82, 83, 84), calculate the data points for each year at each location.

	Location 1	Location 2	Location 3	Location 4	Location 5
	3.35 (81)	2.84 (81)	2.27 (81)	1.70 (81)	1.13 (81)
	3.82 (82)	3.17 (82)	2.45 (82)	1.73 (82)	1.01 (82)
	3.00 (83)	2.65 (83)	2.26 (83)	1.87 (83)	1.48 (83)
	1.27 (84)	1.16 (84)	1.04 (84)	0.92 (84)	0.80 (84)
Average:	2.27	2.46	2.00	1.56	1.10

Step (3) From the above averge values, plot a graph of fish fillet (bottom feeders) TCDD concentration versus distance, which is independent of time (figure 4B), using linear least squares method.

$$\boxed{\begin{array}{c} \ln y = -0.11X + 2.55 \\ r = -0.9373 \end{array}}$$

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Step(4) Calculate the confidence interval based on Student's t distribution, using 95% confidence limits on slope and intercept values.

From 9.2.4.(2).

$N = 20 \Rightarrow 18$ degrees of freedom

$P = 0.025$

$t = 2.101$ (table 4)

$s = 1.8537$

$$\boxed{\begin{aligned} \mu &= -0.11 \pm 0.26 \\ \beta &= 2.55 \pm 0.96 \end{aligned}}$$

9.2.5. Plot a graph of whole fish (bottom feeders) TCDD concentration versus time for location 1 and combined location 2, 3, 4, 5(*) on the Spring River (figure 5A), using linear least squares method.

Apply the similar method [9.2.1.(1),(2),(3),(4)]

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Step(1) data points (table 3c)

Location 1 (1)

$\ln y = -0.24T + 4.61$

$\lambda = -0.3767$

location (+) (*)

$\ln y = -0.22T + 3.72$

$\lambda = -0.9105$

Step (1)(4) Calculate the confidence interval based on Student's t distribution, using 95% confidence limits on slope and intercept values.

* Eq.(1) $\ln y = -0.24T + 4.61$ @ location 1

Table 3c :

$N = 4 \Rightarrow 2$ degrees of freedom

$P = 0.025$

$t = 4.303$ (table 4)

$s = 0.9216$

$$\boxed{\begin{aligned} \mu &= -0.24 \pm 1.77 \\ \beta &= 4.61 \pm 4.86 \end{aligned}}$$

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* Eq. (*) fn $y = -0.22T + 3.72$ @ location *

From table 3C

$N = 3 \Rightarrow$ 1 degree of freedom

$P = 0.025$

$t = 12.706$ (table 4)

$S = 0.2164$

$$\boxed{\begin{aligned} \mu &= -0.22 \pm 1.27 \\ \beta &= 3.72 \pm 3.37 \end{aligned}}$$

Step (2) Use the above equations (1, *), calculate the data points for each year at each location

	1981	1982	1983	1984
	4.37 (eq.1)	4.14 (eq.1)	3.90 (eq.1)	3.66 (eq.1)
	3.50 (eq.*)	3.29 (eq.*)	3.06 (eq.*)	2.94 (eq.*)
Average:	3.93	3.71	3.48	3.30

Step (3) From the above average values, plot a graph of whole fish (bottom feeders) TCDD concentration versus time, which is independent of locations (figure 5B), using linear least squares method.

$$\boxed{\begin{array}{l} \ln y = -0.21T + 4.13 \\ r = -0.9987 \end{array}}$$

Step (4) Calculate the confidence interval based on Student's t distribution, using 95% confidence limits on slope and intercept values.

$$\ln y = -0.21T + 4.13$$

From 9.2.5.(2) $N = 8 \Rightarrow$ 6 degrees of freedom

$P = 0.025$

$t = 2.447$ (table 4)

$s = 0.4749$

$$\boxed{\begin{array}{l} \mu = -0.21 \pm 0.28 \\ \beta = 4.13 \pm 0.54 \end{array}}$$

9.2.6. Plot a graph of fish fillet (bottom feeders) TCDD concentration versus time for location 1 and combined location 2, 3, 4, 6 (location *) on the Spring River (figure 6A), using linear least squares method.

Apply the similar method [9.2.1. (1), (2), (3), (4)]

Step (1) data points (table 3c)

location 1 (1)	location * (*)
$\ln y = -1.15T + 6.14$	$\ln y = -0.44T + 2.82$
$r = -0.9744$	$r = -0.9630$

Step (1)(4) Calculate the confidence interval based on Student's t distribution, using 95% confidence limits on slope and intercept values.

* eq.(1) $\ln y = -1.15T + 6.14$ @ Location 1

From table 3c N = 3 ⇒ 1 degree of freedom

$P = 0.025$

$t = 12.706$ (table 4)

$S = 0.3756$

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$$\boxed{\begin{aligned}\mu &= -1.15 \pm 3.37 \\ \beta &= 6.14 \pm 10.49\end{aligned}}$$

* Eq. (*) $\ln y = -0.44T + 2.82$ @ location *

From table 3C, $N = 4 \Rightarrow 2$ degrees of freedom.

$P = 0.025$

$t = 4.303$ (table 4)

$s = 0.1929$

$$\boxed{\begin{aligned}\mu &= -0.44 \pm 0.37 \\ \beta &= 2.82 \pm 1.02\end{aligned}}$$

Step(2) Use the above equations (1, *) [9.2.6.(1)], calculate the data points for each year at each location.

	1981	1982	1983	1984
	4.99 (eq.1)	3.84 (eq.1)	2.69 (eq.1)	1.54 (eq.1)
	2.38 (eq.*)	1.95 (eq.*)	1.51 (eq *)	1.07 (eq.*)
Average:	3.68	2.89	2.10	1.31

Step (3) From the above average values, plot a graph of fish fillet (bottom feeders) TCDD concentration versus time, which is independent of locations (figure 6B), using linear least squares method

$$\boxed{\begin{aligned} \ln y &= -0.79T + 4.47 \\ r &= -1.000 \end{aligned}}$$

Step (4) Calculate the confidence interval based on Student's t distribution, using 95% confidence limits on slope and intercept values

$$\ln y = -0.79T + 4.47$$

from 9.2.6.(2), $N = 8 \Rightarrow$ 6 degrees of freedom

$P = 0.025$

$t = 2.447$

$s = 0.9999$

$$\boxed{\begin{aligned} \mu &= -0.79 \pm 0.58 \\ \beta &= 4.47 \pm 1.13 \end{aligned}}$$

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TECHNICAL ASSISTANCE TEAM FOR EMERGENCY RESPONSE REMOVAL AND PREVENTION
EPA CONTRACT 68-01-6669

TO:	KENNETH S. RITCHEY, Project Officer U.S. EPA, Region 7	DATE:	05/01/85
FROM:	MARK D. HANSEN/HIEU Q. VU Region 17 Weston TAT	TDD#: TAT#:	17-8502-16 17-F-00740
THRU:	RHETA J. SMITH Region 17 TATL		
RE:	Spring River Fish and Sediment Dioxin Data Statistical Evaluation		

The attached copy is the first draft of the statistical evaluation of the Spring River, Missouri, fish and sediment dioxin data. Region 17 TAT members Mark D. Hansen, Hieu Q. Vu, Corry J. Shedd, David M. Svingen, and Glenn M. Curtis contributed to the EPA file review and data organization. The draft document was prepared by TAT members Hieu Q. Vu and Mark D. Hansen.

Your review/comments are appreciated.

MDH:dr

Attachment

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